STANFORD'S GEOLOGICAL ATLAS OF GREAT BRITAIN AND IRELAND

EDITED BY

H. B. WOODWARD, F.R.S.

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STANFORD'S

GEOLOGICAL ATLAS

OF

GREAT BRITAIN AND IRELAND

[*Based on Reynolds's Geological Atlas*]

WITH PLATES OF CHARACTERISTIC FOSSILS

PRECEDED BY

DESCRIPTIONS OF THE GEOLOGICAL STRUCTURE OF GREAT BRITAIN AND IRELAND AND THEIR COUNTIES; AND OF THE FEATURES OBSERVABLE ALONG THE PRINCIPAL LINES OF RAILWAY

BY

HORACE B. WOODWARD, F.R.S., F.G.S.

SECOND EDITION

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PREFACE

Reynolds's *Geological Atlas* has long been regarded as a useful companion and guide to those, journeying on business or pleasure in Great Britain, who take interest in the geology of the country. The first edition, issued in 1860, was prepared with the assistance of Professor John Morris; and the second edition, published in 1889, was revised by Mr. Robert Etheridge.

In the present volume the general plan of the older work has been followed, but the text has been entirely re-written; fuller descriptions of the geological formations with lists of localities for fossils have been given; the particulars relating to each county have been amplified, regard being paid to the more interesting geological facts, irrespective of the size or industrial importance of the county, and notes on sea-side resorts have been appended; finally, descriptions of the geological features observable along the main lines of railway have been added.

A few of the original text-illustrations have been retained; others have been borrowed from Sir Andrew C. Ramsay's *Physical Geology and Geography of Great Britain.* The figures of fossils are reproduced chiefly from Lowry's *Tabular View of Characteristic British Fossils* and from his *Chart of Characteristic British Tertiary Fossils;* others are taken from the *Chart of Fossil Crustacea*, arranged by Mr. J. W. Salter and Dr Henry Woodward, and a few are from Ramsay's *Physical Geology.* These illustrations will serve to indicate the forms of the leading fossils that are to be met with in our stratified formations.

The maps in the original atlas were based to a large extent on those of the Geological Survey, and they have been revised, as far as the scale has permitted, from the later published maps of that institution, with the help also of Sir Archibald Geikie's Geological Map of Scotland.

The writer is indebted to Dr. John Horne, Mr. E. T. Newton, Mr. F. W. Rudler, and Mr. B. B. Woodward, for friendly advice and assistance.

H. B. W.

HAMPSTEAD.
12th April, 1904.

NOTE TO SECOND EDITION OF STANFORD'S *GEOLOGICAL ATLAS*

THE scope of this work has been enlarged by the addition of a sketch of the geological features of Ireland, its counties and main lines of railway; and the subject is illustrated by a geological map of the country, and by three illustrations borrowed from Professor E. Hull's *Physical Geology and Geography of Ireland*.

Few alterations have been made in the text relating to Great Britain, but the maps have undergone revision, and the Corallian and Portland Beds have been distinguished by stipple from the Oxford and Kimeridge Clays respectively.

A full list has been appended of the Figured Fossils, with indications of their Zoological position and range in time.

The writer, while under further obligations to Mr. Newton, is likewise indebted to Mr. G. W. Lamplugh and Mr. R. L. Sherlock for kind help in the preparation of this new edition.

H. B. W.

HAMPSTEAD.
19th March, 1907.

CONTENTS

	PAGE
GEOLOGICAL STRUCTURE OF GREAT BRITAIN	1
FORMATIONS OF GREAT BRITAIN	13
Igneous Rocks	14
Sedimentary and Metamorphic Rocks	15
MINERAL PRODUCTS OF GREAT BRITAIN AND IRELAND	35
GEOLOGY OF THE COUNTIES OF GREAT BRITAIN—	
England	40
Isle of Man	80
Wales	81
Scotland	88
FEATURES OBSERVABLE ALONG THE PRINCIPAL LINES OF RAILWAY IN GREAT BRITAIN—	
I. London, Tilbury and Southend	102
II. Great Eastern	103
III. Great Northern; North Eastern; and North British	106
IV. Midland; Glasgow and South Western	109
V. London and North Western; Caledonian; Highland	113
VI. Great Central; Metropolitan	118
VII. Great Western	120
VIII. London and South Western	127
IX. London, Brighton and South Coast	130
X. South Eastern and Chatham	131
GEOLOGICAL STRUCTURE OF IRELAND	135
FORMATIONS OF IRELAND	138
Igneous Rocks	139
Sedimentary and Metamorphic Rocks	139

GEOLOGY OF THE COUNTIES OF IRELAND . . 147

FEATURES OBSERVABLE ALONG THE PRINCIPAL LINES OF RAILWAY IN IRELAND 164

I. DUBLIN, WICKLOW, AND WEXFORD . . 164
II. GREAT SOUTHERN AND WESTERN . . . 166
III. MIDLAND GREAT WESTERN . . . 168
IV. GREAT NORTHERN; SLIGO, LEITRIM, ETC. . . 169
V. MIDLAND (NORTHERN COUNTIES' SECTION) . . 171

LIST OF FIGURED FOSSILS 173

INDEX 184

LIST OF SECTIONS AND VIEWS

			PAGE
Fig.	1.	Section from the Grampians to the Lammermuir Hills	5
,,	2.	Section across the Pennine Anticline . .	5
,,	3.	Section from North Wales across the Malvern Hills to the Essex Coast	5
,,	4.	Section across the Wealden Area . . .	6
,,	5.	Diagram Section across the London Basin . .	11
,,	6.	Section of Purbeck Beds, Isle of Portland . .	26
,,	7.	View in the Pass of Llanberis . . .	36
,,	8.	Section near Redruth showing Metalliferous Veins .	44
,,	9.	Blue John Mine, Castleton . . .	46
,,	10.	The Landslip of Dowlands and Bindon, between Axmouth and Lyme Regis	48
,,	11.	Section across the Isle of Purbeck . . .	49
,,	12.	Section in the Forest of Dean . . .	53
,,	13.	Section across the Isle of Wight . . .	54
,,	14.	The Stiper Stones	67
,,	15.	Section across the Silurian Rocks of Wenlock Edge .	67
,,	16.	Section across the South Wales Coal-field . .	85
,,	17.	Diagram Section of the Rocks in Sutherland and Caithness	100
,,	18.	Section across the Lakes and Mountains of Killarney	137
,,	19.	Section through Cuilcagh and the Marble Arch, Florence Court, Enniskillen . . .	137
,,	20.	Section across the Leinster Coal-field , .	155

LIST OF GEOLOGICAL MAPS

INDEX TO GEOLOGICAL MAPS—PRINCIPAL ORGANIC REMAINS OR FOSSILS *Folding Table.* PAGE 1

GREAT BRITAIN . . . . . *Frontispiece.* PLATE

ENGLAND:

	PLATES		PLATES		PLA
BEDFORDSHIRE .	2	HUNTINGDONSHIRE .	4	RUTLANDSHIRE .	.
BERKSHIRE .	3	ISLE OF WIGHT .	15	SCILLY ISLES .	.
BUCKINGHAMSHIRE .	2	KENT .	17	SHROPSHIRE .	25
CAMBRIDGESHIRE .	4	LAKE DISTRICT .	8	SOMERSETSHIRE .	11
CHESHIRE .	5	LANCASHIRE .	18	STAFFORDSHIRE .	26
CORNWALL .	6	LANCASHIRE, NORTH .	8	SUFFOLK .	.
CUMBERLAND, NORTH	7	LEICESTERSHIRE .	19	SURREY .	4
CUMBERLAND, SOUTH	8	LINCOLNSHIRE .	20	SUSSEX .	
DERBYSHIRE .	9	LONDON .	2, 13, 17, 28	WARWICKSHIRE .	
DEVONSHIRE .	10	MIDDLESEX .	2	WESTMORLAND .	
DORSETSHIRE .	11	MONMOUTHSHIRE .	16	WIGHT, ISLE OF .	
DURHAM .	12	MONMOUTHSHIRE, WEST	32	WILTSHIRE, NORTH	
ESSEX .	13	NORFOLK .	21	WILTSHIRE, SOUTH	
GLOUCESTERSHIRE .	14	NORTHAMPTONSHIRE .	22	WORCESTERSHIRE .	
HAMPSHIRE .	15	NORTHUMBERLAND .	23	YORKSHIRE, WEST	
HEREFORDSHIRE .	16	NOTTINGHAMSHIRE .	24	YORKSHIRE, EAST .	
HERTFORDSHIRE .	2	OXFORDSHIRE .	3		

	PLATES
ISLE OF MAN .	7
WALES, NORTH .	31
WALES, SOUTH .	32
SCOTLAND, NORTH .	33*a*
SCOTLAND, SOUTH .	33*b*
IRELAND, NORTH .	34*a*
IRELAND, SOUTH .	34*b*

LIST OF PLATES OF FOSSILS

	PLATES		PLATES		I
CAMBRIAN AND ORDOVICIAN .	35	LIASSIC AND LOWER OOLITIC .	40	UPPER CRETACEOUS	
SILURIAN .	36	LOWER OOLITIC .	41	LOWER EOCENE .	
DEVONIAN AND OLD RED SANDSTONE .	37	MIDDLE OOLITIC .	42	UPPER EOCENE .	
CARBONIFEROUS .	38	UPPER OOLITIC AND WEALDEN-PURBECK .	43	OLIGOCENE .	
PERMIAN, TRIASSIC AND LIASSIC .	39	LOWER AND UPPER CRETACEOUS .	44	PLIOCENE .	
				PLEISTOCENE .	

GEOLOGICAL STRUCTURE OF GREAT BRITAIN.

GREAT BRITAIN, the largest island of Europe, is an outlying portion of the mainland, with which it is intimately connected in geological structure. The Straits of Dover form but a notch in the great Chalk formation which there extends below the Channel, and is so well shown in the white cliffs on either side. Other geological formations are probably persistent beneath the sea-bed, and while some ancient links are now dissevered, there is abundant evidence of former union. An elevation of six hundred feet would connect all the British Isles with the mainland, and less than half that uplift would restore the bond across the eastern part of the Channel.

From Beachy Head to Cape Wrath the length of Great Britain is 587 miles, while its breadth from the Land's End to the South Foreland is 316 and to Lowestoft 367 miles.

Over this large area of 88,006 square miles there is a great variety of rocks, noticeable to all who travel through the land; granite, schist, and slate and other hard rocks in mountain regions, clays and limestones, sands and gravels chiefly in the lower lands. It seems natural that the harder and usually older rocks should form the higher grounds, which attain an elevation at Ben Nevis of 4400 feet, while the lesser hills, the vales and plains are formed of softer and, for the most part, newer strata. So on the coast, which in England and Wales extends to 2350 miles and in Scotland to 2500 miles, the alternation of harder and softer rocks has led to the production of headlands and bays—the relative hardness rather than the age of the rocks being the important factor. We may agree with Tennyson that

> "No rock so hard, but that a little wave
> May beat admission in a thousand years,"

but the harder rock will form a promontory if it be bordered by rocks more easily worn away by the breakers, aided as these are in all cases by the action of rain and frost on the cliffs.

Inland while relative hardness is important, so also is the texture of the strata, whether porous or impervious. Thus rain sinks through sands and gravels, and erodes clays; and in areas composed of these strata the dominant features may be formed of the looser materials.

The object of geology is not merely to explain the origin of the present physical features, but also to picture the many changes in the distribution of land and water and in the forms of life which have occurred in the past. The present is but the latest phase of geological history, and a study of all that is going on now over the surface of the earth enables us to explain what has happened in our own country in the bygone periods. Here as elsewhere we observe continual change. The waste along the sea-coast is almost everywhere apparent, and in some parts disastrous. The waste inland is not always so manifest. Muddy streams in times of heavy rain, occasional landslips, the screes of tumbled rock below scarps of hard rock, tell of waste and of material that may be rolled into gravel and transported along the river courses. The inland caverns whence limestone has been removed by dissolution, the mineral springs, and the materials held in solution as well as in suspension by our rivers, bear testimony to ceaseless destruction.

Everywhere, whether in organic or inorganic nature, there is growth and decay, the accumulation of material in one area and its removal from another; and our stratified rocks are mainly old sediments worn from the land and spread out on the sea-floor, together with shells, bones, and other hard parts of various animals, and remains of plants.

If in this country we have no deserts, no active volcanoes, no glaciers, no modern coral reefs, yet we have evidence that in past times the area occupied by the British Isles exhibited now and again these conditions. If we have no actual volcanic cone we have the "basal wrecks" and other evidences of great centres of eruption, in masses of granite and gabbro, in piles of lavas and ashes. Moreover, we have evidence of the increased heat beneath the earth's surface from the records of deep mines where the temperature rises 1° for every sixty feet, and in hot springs like those of Bath.

In Great Britain there are representatives of all the principal geological periods. Permanent as our land seems now to be, excepting for the waste of its surface, and an occasional earthquake, due to the rupture of rocks at a depth, yet the area has been a very unstable one in the past owing mainly to repeated upheaval and depression of the solid crust; but partly perhaps to fluctuations in the sea, for under certain physical conditions its actual level does vary considerably in different areas.

Throughout geological time, that is of those periods of which we have evidence in the rocks exposed at the surface or proved in deep borings, there is no doubt that the agents were similar in kind, and there is no certain proof that they were more powerful and violent in the early than in the later epochs. Great volcanic activity affected our area in the Ordovician, Devonian, Carboniferous, Permian and early Tertiary periods, and some of the chief mountain systems have received uplifts of great magnitude in these later times, when, for instance, the Chalk of the Dorset Coast and the Isle of Wight was tilted into a vertical position. We must not, indeed, judge of the past simply by what is going on in this country at the present time.

One of the earliest of geological lessons is that all kinds of sediment are being laid down in various subaqueous areas, from coarse detritus to fine mud, and to deep-sea ooze which is mainly organic. Moreover, there is a gradual change in the character of the fauna existing on rocky ground or on mud or sand, at different depths, and at varying distances from the sea margin.

Thus when we come to consider our stratified formations, some composed of great masses of clay, others mainly of sandstone or limestone, and some of mixed character, we must recognize that only limited portions of the sea-bed and of the life of the period can be represented in the rocks. In considering the history of England, Wales and Scotland we have the same partial record of events, local and general, materials derived from parish and county and those relating to state and rulers: portions only of the history of the world.

We divide our history into Norman, Tudor and other periods for convenience, without any thought of a break or cessation of events, unless that which in England was marked by the incoming and occupation of the Romans. So in our geological history the great formations are grouped together in larger and smaller periods without implying any pauses or sudden and universal changes. Some of the larger chronological terms are used all the world over—such group-names as Silurian, Carboniferous, Jurassic: but when we come to the formations composing these systems we must necessarily be local, and each country finds it needful to have its own nomenclature, because the beginnings and endings of the formations do not correspond over large areas. Even in this country we have to sub-divide differently in distant areas, and a great and increasing number of stratigraphical names is a necessary consequence. There is, however, a means of correlation.

Certain genera have been found to have a wide distribution in space and a comparatively limited distribution in time so far as the species are concerned; and they have been chosen to distinguish life *zones* in the strata. Among these forms of life, trilobites, graptolites and ammonites have proved of the greatest service, while belemnites, brachiopods, echinoderms and other organic remains, even fishes and plants, have likewise been found useful.

As these zones are independent of the lithological characters of the strata, so they cannot be expected to correspond with the stratigraphical divisions or formations which mark the persistence over restricted areas of certain physical conditions. The limits of zones depend on the occurrence of fossils, hence they are Palæontological or Zoological rather than stratigraphical, because they cannot be defined by sediment. In all field-work, however, an intimate knowledge of the local characters and succession of the strata is of the utmost importance. The succession of life is established from the succession of the strata.

In the oldest rocks we find only the lower organisms, the great groups of invertebrata differing for the most part largely from the genera now existing; but as we ascend the series of strata higher and higher forms of life, fishes, amphibians, reptiles, birds and mammalia gradually appear, alongside the modified forms of invertebrates, all approaching more and more in character to the living animals and plants.

This history extends over a period that is estimated at about 100,000,000 years—a period during which geological events succeeded one another without pause, but with repeated change, when land areas became submerged or sea-beds were upraised to form dry land.

Thus while the story told by British geology is no more identical in detail, with that of other regions of the earth's surface, than is that of British history, there are yet many features in common in the life-history, and perhaps more in common during the earlier than the later epochs.

The fossils or organic remains are variously distributed in the rocks, being sometimes very abundant as in the Crag, in the earlier Tertiary strata of the Isle of Wight and Hampshire, in the Chloritic Marl of Dorset, the Inferior Oolite of Dorset or of Stroud; but in many a famous locality good specimens are only to be obtained after prolonged labour.

The older rocks occupy the northern and western parts of Great Britain. In this country they are, as a rule, much harder than the succeeding (Secondary and Tertiary) strata. Naturally they have been subject to more compression, to more alteration by igneous intrusion and chemical agency, than the later formations. Gneiss and granite, greenstone, schist, slate, sandstone and grit with subordinate limestone, characterize the rocks known as Archæan and the lower Palæozoic; limestones, sandstones, and shales, with many igneous rocks, prevail among the higher Palæozoic. The older of these form the Outer Hebrides or Long Island, the Highlands and Southern Uplands of Scotland (Fig. 1), the Lake District, Wrekin, Charnwood Forest, Malvern, and the mountainous parts of Wales and the Isle of Man. The newer occupy the midland valley or central trough of Scotland between Highland and Southern Upland (Fig. 1), with many a crag of harder igneous rock; they rise up in the Fells of Northumberland which extend from the western borders of Cheviot southwards to Derbyshire, forming the broad and locally faulted anticline of the Pennine range (Fig. 2); they constitute the Brecknock Beacons and the higher grounds of Glamorganshire, the Mendips, Quantocks, and great part of Devonshire and Cornwall.

The older of these rocks are much folded, highly inclined, often crushed, and sometimes overthrust; the newer Palæozoic as a rule (except in Devon and Cornwall) are bent into comparatively gentle folds, such as the Pennine anticline (Fig. 2), the syncline of the South Wales Coal-field or the Forest of Dean, the anticlines of the Mendips.

These disturbances were effected prior to the deposition of the Permian and newer strata, as the Magnesian Limestone, which sometimes appears locally conformable, in reality rests indifferently on the disturbed and greatly eroded surfaces of various members of the Carboniferous rocks. The Permian, though often grouped with the Palæozoic, forms the natural base of the Secondary group, and is succeeded with general conformity by the overlying Trias, and the Jurassic divisions. These strata form the broad belts of hills and vales which characterize the central parts of England, extending to Dorset on the south, east Yorkshire on the north, to the Dee Valley, the Vale of Clwyd, and the Vale of Eden on the north-west.

In this group we have a series of escarpments facing generally the north-west or west, and including the Cleveland and Hambleton Hills in Yorkshire, the Lincoln Cliff, Edge Hill in Warwickshire, and the Cotteswold Hills, with intermediate vales.

These are followed in an easterly or south-easterly direction by the Chalk Wolds of Yorkshire and Lincolnshire, and by those of Royston,

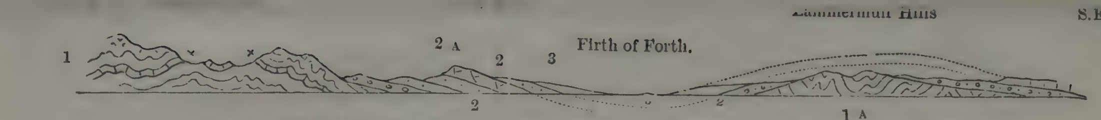


FIG. 1.—SECTION FROM THE GRAMPIANS TO THE LAMMERMUIR HILLS. (*Ramsay.*)

1A. Ordovician and Silurian.
1. Highland schists with bands of quartzite, &c.
3. Carboniferous.
2. Old Red Sandstone with volcanic rocks, 2A.

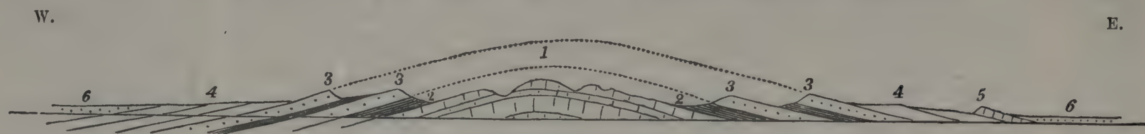


FIG. 2.—SECTION ACROSS THE PENNINE ANTICLINE. (*Ramsay.*)

3. Scarps of Millstone Grit.
2. Yoredale Shales.
1. Carboniferous Limestone.
6. Trias.
5. Magnesian Limestone (Permian).
4. Coal-measures.

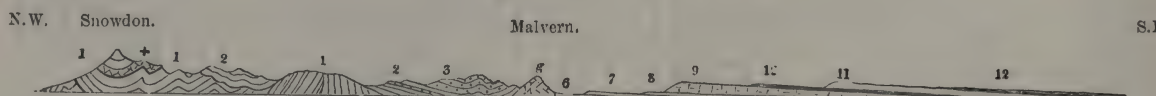


FIG. 3.—SECTION FROM NORTH WALES ACROSS THE MALVERN HILLS TO THE ESSEX COAST. (*Ramsay.*)

3. Old Red Sandstone.
2. Silurian.
1. Ordovician, Cambrian, and Pre-Cambrian.
\+ Eruptive rocks.
g. Gneiss of Malvern.
12. Eocene.
11. Chalk of Chiltern Hills.
9, 10. Oolites of Cotteswold Hills
7, 8. Lias.
6. Trias.

Luton and Dunstable, which merge into the Chiltern Hills. Further south the Chalk ranges are prolonged into the Wiltshire and Dorsetshire Downs, and eastward into the North and South Downs, which border the anticline of the Weald (Fig. 4).

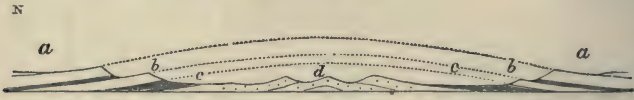


FIG. 4.—SECTION ACROSS THE WEALDEN AREA. (*Ramsay.*)

a a, Upper Cretaceous strata, chiefly Chalk, forming the North and South Downs, underlaid by Upper Greensand and Gault. *b b*, escarpment of Lower Greensand with a valley of Gault between it and the Chalk. *c c*, Weald Clay, forming vales. *d*, hills formed of Hastings Beds. The Chalk, &c., once spread across the country, as shown in the curved and dotted lines.

The Tertiary strata occupy synclines in the Chalk, known as the London and Hampshire Basins, and are highly tilted in the Isle of Wight (p. 54) and South Dorset. They form a low plain in East Anglia.

The various groups of strata have been affected by uplifts in diverse directions, and these disturbances have been grouped into (1) the *Caledonian*, with the axis of folding or lines of faulting in a N. E. and S. W. direction, corresponding with that of the Great Glen of Scotland; (2) the *Malvernian*, having the direction N. and S., as in the Malvern Hills, the Pennine anticline; (3) the *Armorican* (of Brittany) having an E. and W. direction, as in the Mendip anticlines and in that of the Weald; (4) the *Charnian*, corresponding with the trend of the folding in Charnwood Forest, N. W. and S. E. These terms are used by Prof. Lapworth to indicate the direction of movements irrespective of their age, movements whether of folding or faulting having taken place along the same lines or planes of weakness or in the same directions at successive periods.

While the strata from the Permian and Trias (New Red rocks) to the Purbeck and Wealden appear everywhere generally conformable, the succeeding Lower Greensand stretched irregularly across an eroded plane of these earlier formations, and is thus found on the Kimeridge clay in Wiltshire and on the Corallian rocks in Oxfordshire. The Upper Cretaceous strata again extended over a much wider area, overstepping all the Jurassic divisions, as in Dorsetshire, resting immediately on the New Red rocks in Devonshire, and irregularly overlapping the Lower Greensand in the Vale of Wardour, also near Swindon and Oxford.

The uptilting of the Jurassic rocks presents features of interest as we proceed northwards from Dorsetshire to Warwickshire. In the south the escarpment of Forest Marble is the most prominent among the ranges of hills, near Bath the Great Oolite is conspicuous, near Cheltenham the Inferior Oolite dominates in the Cotteswold Hills, and further north the Marlstone in Edge Hill. These rocks were to some extent folded and faulted, as in Dorset, prior to the submergence which led to the Cretaceous overlaps.

The Tertiary deposits, except in the Bovey Basin in Devonshire and in the Inner Hebrides, rest on Chalk which must have spread at one time far and wide over the area of South Britain. The Eocene pebble-beds are almost wholly formed of flint, except in West Dorset where an ancient river from the regions of Devon brought other materials.

The history of our rivers is a complex subject. Looked at from the present point of view the mountains and uplands form the chief sources, the glens and valleys the channels. The Highlands and Southern Uplands of Scotland with an off-shoot through the Cheviots; the Pennine Chain with the Lake Mountains; the group of mountains in North Wales, extending southward to Plynlimmon and other hilly regions in South Wales; the Cotteswolds and to some extent the Oolite escarpment that ranges from Bath to the southern borders of Somerset, form watersheds, and these are diverted westwards through the hilly ground of North Devon and Cornwall, and eastwards through Wiltshire and the Weald. Yet there are notable exceptions in these water-partings. The Lower or Bristol Avon rises along the dip-slopes of the Cotteswolds and turning round from a south-easterly to a westerly course it cuts through the Oolite escarpment between Bradford-on-Avon and Bath, and through the Carboniferous Limestone in the rocky gorge of Clifton ere it reaches the Bristol Channel. The Thames intersects the great Chalk range at Streatley and Goring. Evidently these rivers must have commenced their courses before the bordering low-lands were widely excavated.

If we follow the teachings of Jukes and Ramsay, and the nomenclature of Prof. W. M. Davis, we may infer that the rivers took their primary or "*consequent*" courses over plains of deposition and erosion in accordance with the general tilt of uplifted tracts. Lateral drainage produced "*subsequent*" streams, approximately at right angles to the main river; and again these tributaries were fed by "*obsequent*" brooks, that may have flowed parallel with or directly opposite to the course of the main river. The cutting back of the diverse courses of such a river system led to the connection of some previously distinct drainage areas and to the partition of others, for by the extension of lateral streams other consequent rivers were "beheaded." This subject furnishes almost endless interesting problems, because there are many possible solutions owing to modifying influences due to the character of the geological formations, to the folding and faulting to which they have been subjected, and likewise to the ancient surfaces of erosion, which have been revealed, as in the lower course of the Bristol Avon, by the denudation of later times.

The Miocene period appears to be unrepresented by deposits in this country, and it was probably a period of extensive land waste, when escarpments were formed or initiated by subaërial erosion. In our midland areas in England Jurassic escarpments were produced after much erosion of the Chalk and other Cretaceous strata, which formerly spread over them. By this erosion, which commenced in early Tertiary times, and was partly subaërial and partly marine, much of the Chalk was planed down or removed from the western counties.

If we fill up the valleys that have since been excavated in the

Jurassic rocks to the level of what may have been the original plane of marine denudation, the amount to be removed in the formation of the escarpments is by no means great. So when the dome of the Weald was planed down (see Fig. 4, p. 6) the Chalk has not necessarily been wasted back over very extensive areas by subaërial erosion, in order to form the present escarpments; but it is clear that the present rivers must have taken their courses north and south from the central watershed before the escarpments of the North and South Downs were formed.

Outliers afford some indication of the former extent of scarps, when the strata are but slightly inclined. Their severance may be attributed to the effects of subterranean drainage and erosion, whereby channels were produced in the impervious clays which underlie the permeable strata, such as sands and limestones, of which so many outliers are composed. Slight subsidences took place along the lines of underground erosion, paving the way for the disconnection of portions of the main mass of strata to form outliers. Faults and dislocations, as well as gentle synclinal structures, have sometimes aided in their preservation. Of such outliers, Brent Knoll, Glastonbury Tor, and Dundry Hill in Somerset, Robinswood, Churchdown, Dumbleton, and Bredon Hills in Gloucestershire, are examples.

There is no doubt that the broad outlines of our escarpments were marked out before the Glacial period, before the main Boulder-clay was laid down. We find this glacial accumulation alike on upland and in vale, at any rate, in the Midland Counties—though when we come southwards its progress seems to have been barred to some extent by the Chiltern Hills, and more definitely by Edgehill and the northern Cotteswolds. The absence of outliers along the borders of the Lincolnshire cliff is noteworthy. The region was one subjected to glaciation, and when we find large transported masses of Lincolnshire Limestone and Marlstone in the Boulder-clay to the south, it is not unreasonable to infer that such masses are relics of outliers which formerly existed to the north.

Again, there has been considerable denudation since the Boulder-clay was spread over the land, as valleys have been scooped through it, and the Glacial Drift has been separated into many an outlying mass. In East Anglia especially, the minor features are largely due to the erosion of the thick coverings of Drift. Boulder-clay likewise filled up many an old valley, more especially in the Northern Counties, and the subsequent river erosion has sometimes followed quite different courses, while here and there the buried channels have been proved by mining or well-boring operations. Elsewhere deep channels were cut by overflow-waters from lakes impounded by land-ice.

The great sequence of formations has been ascertained from actual observation in quarries, cuttings, and cliffs, and from the records of wells and deep borings. That the Secondary and Tertiary strata of the Midland, Eastern, and Southern Counties rest on a floor of folded and eroded Palæozoic rocks has been proved in many a deep boring. Ancient slaty rocks of unknown age have been found in Suffolk at Stutton, and in Essex near Harwich, beneath the Gault. Similarly, Silurian rocks have been proved at Ware, and Devonian rocks at Cheshunt, in Hertfordshire. Further south, Oolitic rocks intervene, and under London, after penetrating the Made Earth, Thames Valley gravel, London Clay, and Lower London Tertiaries, the Chalk, Upper Greensand and Gault, there have been found at a depth of about one thousand feet, strata of Great Oolite like those which come to the surface about one hundred miles to the west; while below these are rocks of the character of the Devonian. Again, at Chatham, Oxford Clay has been reached at a depth of 943 feet; and at Dover, beneath Chalk and other Cretaceous and Jurassic strata, Coal-measures have been proved at a depth of 1100 feet 6 inches. No one can say how far that coal-field may extend, nor can anyone say what other tracts of Coal-measures may be preserved in the south and east of England in the large areas as yet unexplored.

Our object, however, is to consider the surface areas where the various formations are exposed, the limits of which are depicted on the geological maps. These maps show mainly the "solid" formations, as they are termed, irrespective of the superficial coverings of Boulder-clay and gravel which enter largely into the surface geology of the Eastern, Midland, and Northern Counties of England, and of large parts of Scotland and Wales.

To depict these drift deposits with any approach to accuracy on the small scale of the maps in this volume has been found impracticable.

It will be observed that the great groups of strata, the Archæan, Palæozoic, Secondary and Tertiary, have each had special influence on the character of the land and on its population. In the two older groups the fractures and crevices of the rocks have in certain tracts been filled with metalliferous deposits, while elsewhere masses of granite, slate, paving and building-stone, and large tracts of productive coal-measures have been preserved. In these regions the population has grown in accordance with the development of industries. Large areas of the old rocks, where little soil can accumulate, or the conditions are unfavourable for agriculture, forming mountainous grounds, great moorlands and fells, happily remain as upland pastures, woodlands, deer forests and grouse moors, invaluable as health resorts and areas of recreation and sport. In those regions the houses are mostly stone-built, and the land is divided by stone-fences.

Among the Secondary rocks we find some of our chief pastoral regions. The strata are soft and readily decomposed into soils. The clay-vales give rise to rich pastures and orchards, and they form the more famous hunting-districts, from the Vale of Blackmore in Dorset, to that of White Horse in Berkshire, Bicester, Whaddon, Pytchley, Quorn, Cottesmore, and the Vale of Belvoir. Alternating with the vales are the stonebrash hills, fertile arable lands adapted for cereals and roots; and along these belts we find many valuable building-stones, those of Portland, Bath, Ancaster, &c., and the chief source of our iron-ore, as near Wellingborough, Kettering, Grantham, Frodsingham, and the Cleveland Hills. In this Secondary region we find groups of villages for the most part stone-built with stone-tiled roofs and porches, and stone-fences, intermixed with other villages brick-built, and with luxuriant and well-timbered hedgerows on the clay tracts. In these areas, as at Peterborough, some of our largest brick-yards are found.

In Tertiary tracts, formed largely of gravels, sands, and clays, and in the districts covered by Glacial Drifts and valley gravels, the ground is chiefly agricultural, but with good hedgerows, much woodland, and pleasant breezy gorse-covered commons. The beneficial effects of the Glacial Drifts are noticeable in the north-east of Scotland, where oats and barley are largely cultivated.

In England and Wales about three-quarters of the land is under cultivation, apart from woods and plantations, in Scotland about one-quarter; while the population in England is reckoned at 606, in Wales 230, and in Scotland 150 per square mile.

The soil is the top covering of earth from a few inches to a foot or more in depth, made up most largely of weathered subsoil, with an admixture of decayed animal and vegetable matter or humus, and with a certain amount of wind-drifted material, the whole acted upon in various ways by plant-growth, earthworms, and micro-organisms.

While soils thus largely owe their mineral ingredients to the subjacent strata or subsoils, they have in many cases been washed down slopes over the surfaces of strata with which they can have but a partial relationship, or, perhaps, no relationship at all. The depth of soil is greatly influenced by the nature of the subsoil, and the configuration of the ground.

Strictly speaking, the subsoil is the geological formation which lies immediately beneath the soil, although the term has sometimes been restricted to the weathered and disintegrated portions of the subjacent rock. This restriction cannot, however, be maintained. On the Chalk formation, for instance, the soil is sometimes exceedingly thin; a ploughed field may look brown and loamy, but an adjacent Chalk-pit may show but a few inches, or hardly a perceptible trace of soil. In such instances the Chalk is clearly the subsoil. On stiff clays again there is often but a skimming of soil. This is the case in areas of London Clay, and it may be experienced in some London gardens where London Clay is distinctly the subsoil. Clay-vales locally have their heavy soils ameliorated by downwashes of lighter materials from bordering hills, so that on isolated hills and on the brows of uplands less soil and a less amount of weathered subsoil are to be expected than on plateaus or in vales.

That subsoils possess infinite variety in structure and composition may be gathered from a study of the lithological characters of the many geological formations, which include limestone, slate, sandstone, conglomerate and other hard rocks, as well as marl, clay, loam, sand, gravel, and other soft and loose materials. Some formations are fairly uniform masses of strata of considerable thickness; others, like the Forest Marble, the Reading Beds, and the Glacial Drifts, exhibit great diversity of character within narrow limits, and yield mixed soils. All are more or less subject to modification where they approach the surface, through the influence of frost and rain; harder rocks are broken up, calcareous rocks are partially dissolved away, while those which are grey or dark blue at a depth become a rusty brown through decomposition of the iron-salts which they contain. The depth of the weathered rock beneath the actual soil thus varies considerably in different areas even on formations of similar age and character. To estimate fully the agricultural capabilities of an estate, it is not enough to know the general characters and depth of the soils, to have chemical analyses of them, and to be acquainted with the nature of the subsoils, while due heed is given to the conditions of elevation, aspect, and rainfall. We must also have "mechanical analyses" of the soils, or a determination of the size and composition of their finer constituents, as the available plant food, upon which their natural fertility is dependent, is influenced by their texture and power of absorbing and retaining moisture. Only when due heed is paid to these varying conditions and circumstances is it possible to determine the kind of natural or artificial manures by which the fertility of the land may be maintained or increased.

Rain sinks into the porous strata, gravels, sands, sandstone, and limestone, or into crevices of hard rocks, and flows off the clays and other dense strata. The porous strata become charged with water

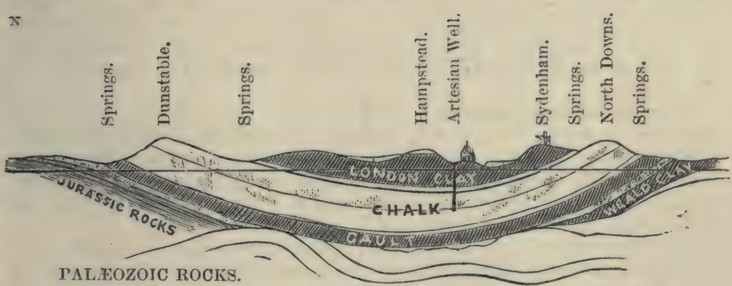


FIG. 5.—DIAGRAM SECTION ACROSS THE LONDON BASIN.

until they can retain no more, and the surplus flows away in springs. This overflow depends on the position of the porous strata. If they form the capping of a hill, and are based on impervious rocks, there can be no great storage of water, except in hollows and irregularities of the floor. The water sinks and escapes around the margin of the hill, in definite springs or by weeping or "seepage."

Where the porous strata under similar circumstances occupy extensive tracts, large villages and towns may have grown up, supplied with water from wells and pumps, until either the demand was too great for the limited yield of water, or because through defective drainage the soil had become so polluted that the supply was condemned. Thus many shallow or ordinary surface wells have had to give place to deeper wells or distant sources of supply.

Where the porous strata extend in a syncline below a large area, and are overlain and underlain by impervious strata, they may yield copious supplies for wells, as in the case of the Chalk beneath London (Fig. 5). This formation receives the rainfall on the Chiltern

Hills and Dunstable and Royston Downs on the north, and on the North Downs to the south. Springs are given out at the surface from the saturated Chalk both near its base at the junction with the clayey Chalk marl, and at top where the covering of Eocene clays on lower ground likewise causes an overflow. When deep wells are sunk through the London Clay into the Chalk, and encounter one or more fissures in it, the water freely enters the well or bore-hole, and naturally rises to about the level of the plane of the saturation in the Chalk (see Fig. 5).

Pumping operations, however, tend to diminish the flow of the springs, the plane of saturation in the Chalk becomes lowered, and after a time the water, which can percolate but slowly through the Chalk, may not be supplied in the centre of the basin in quantity equal to the many and increasing demands made upon it. In some cases the water, which naturally overflowed into one drainage area, may be pumped up and conveyed elsewhere to find its way as waste water into a distinct area.

The deep wells above noted are known as artesian, and the water having to travel some distance below ground through the Chalk becomes filtered. When, however, it is obtained from harder rocks, like the Carboniferous Limestone, where the joints and fissures may be open to the surface, dependence cannot be placed on the purity of the water.

In mountainous regions, formed of hard and for the most part impervious rocks, the rain is rapidly drained off, unless stored to some extent in peaty beds, or in shattered surface-strata. Reservoirs formed by the damming of valleys are usually necessary to provide a suitable supply of water to the larger towns and villages in the lower lands bordering these areas.

The diversity of our formations, and the varying elevations and aspects of the land, furnish many and almost bewildering varieties of sites for those able to choose their place of residence.

It must be remembered that most of our geological formations vary a good deal in character, and that even those which are naturally commended for their dryness, are likely to be water-logged in low situations. Thus gravels and sands may be damper in low situations than clays. In hilly tracts the surface waters drain rapidly off a clayey surface, and only tend to accumulate or flow away sluggishly in the lower grounds.

The driest tracts are those composed of porous strata of gravel, sand, sandstone, or limestone, well above the open watercourses, and in masses sufficiently thick for the ground-waters to be carried to some depth below the foundations of the buildings.

Such tracts may be found at Brentwood, St. Albans, Watford, Rickmansworth, Bromley, Croydon, Sutton; or, to go further, in places like Woking, Hindhead, Reigate, Tunbridge Wells, Woburn Sands, or Devizes.

There are many who seek a country house on a dry soil, well elevated, with bracing air, a good water supply, fine trees and good garden land, near a main line, and perhaps in the vicinity of a hunting country. The hunting grounds are, of course, mainly the clay vales with their meadows and pastures; the driest grounds are neither favourable for the production of fine trees, excepting firs, nor for gardens.

There is, perhaps, hardly a locality in town or country where a damp insanitary house may not be found. On the other hand, there are comparatively few large areas in which healthy sites may not be met with. Much depends on the building itself and the water supply, the aspect, and the general surroundings: and a great deal on the tastes and occupations of the individual.

FORMATIONS OF GREAT BRITAIN.

SEDIMENTARY AND METAMORPHIC ROCKS.

Era	Division	Series	Beds	Group	Thicknesses in feet.
Cænozoic	Quaternary	Recent or Holocene	Alluvium with peat, Blown Sand, Estuarine and Marine beds: of Neolithic and later ages		up to 60
		Pleistocene	River Gravel and Brickearth, Raised Beaches: of Eolithic and Palæolithic ages		30
			Glacial Drift		200
	Tertiary	Pliocene	Cromer Forest Bed Series		30
			Norwich and Red Crags		up to 150
			Coralline Crag and Lenham Beds		40 to 80
		Oligocene	Hamstead Beds	Fluvio-marine Series	260
			Bembridge Beds		110
			Osborne Beds		100
			Headon Beds		150
		Eocene	Barton Sands, Barton Clay	Upper Bagshot Beds	400
			Bracklesham Beds		400 to 650
			Lower Bagshot Beds		100 to 600
			London Clay		50 to 480
			Oldhaven and Blackheath Beds		10 to 60
			Woolwich and Reading Beds		15 to 150
			Thanet Beds		20 to 60
Secondary or Mesozoic		Cretaceous	Chalk		up to 1750
			Upper Greensand	Selbornian	40 to 120
			Gault		100 to 250
			Lower Greensand		250 to 600
		Wealden-Purbeck	Weald Clay, Hastings Sands	Wealden	1500
			Purbeck Beds		50 to 400
	Jurassic	Oolitic Series	Portland Beds		80 to 300
			Kimeridge Clay		100 to 1200
			Corallian Beds		50 to 200
			Oxford Clay and Kellaways Beds		300 to 600
			Cornbrash		5 to 30
			Forest Marble, Bradford Clay, and Great Oolite Clay; Great Oolite and Stonesfield Slate	Great Oolite Series	130 to 350
			Inferior Oolite Series, including Midford Sand (passage-beds)		15 to 250
		Liassic	Upper Lias		25 to 200
			Middle Lias		50 to 350
			Lower Lias		450 to 960
	New Red Sandstone	Triassic	Rhætic Beds		30 to 120
			Red Marl and Sandstone (Keuper)		500 to 1500
			Red Sandstone and Pebble-Beds (Bunter)		1000 to 2000
		Permian	Magnesian Limestone Series; Red Sandstone, Breccia, and Conglomerate		500 to 1500

			Thicknesses in feet.
Primary or Palæozoic	CARBONIFEROUS	Coal-measures	2000 to 8000
		Millstone Grit	up to 4000
		Carboniferous Limestone Series and Calciferous Sandstone	800 to 4000
	OLD RED SANDSTONE and DEVONIAN	Upper Old Red Sandstone, Devonian, Lower Old Red Sandstone	2000 to 4000
	SILURIAN	Ludlow Series	700 to 1400
		Wenlock Series	2000 to 4000
		May Hill or Llandovery Series	2000 to 3000
	ORDOVICIAN	Bala and Caradoc Series	4000 to 12,000
		Llandeilo Beds	3000 to 4000
		Arenig Series	1000 to 2500
	CAMBRIAN	Tremadoc Series	1000
		Lingula Flag Series	4000 to 5000
		Menevian Series	600 to 750
		Harlech Series	3000 to 8000
Pre-Cambrian and Archæan	TORRIDONIAN	Torridon Sandstone and Longmyndian	
	URICONIAN	Wrekin Volcanic Series, Pebidian, &c.	
	DALRADIAN	Highland Schists	
	LEWISIAN	Hebridean or Fundamental Gneiss	

IGNEOUS ROCKS.

Acid.	Granite, Quartz-porphyry, Felsite, Pitchstone, Rhyolite
Intermediate.	Syenite, Diorite, Andesite, Trachyte
Basic.	Gabbro, Diabase, Dolerite, Basalt
Ultra-basic.	Serpentine

In the following brief account of the geological formations, the figures and names in **clarendon type** refer to those which are distinguished on the accompanying maps.

IGNEOUS ROCKS.

Igneous rocks are naturally of all ages, from the very earliest periods of which we have records until the present time. In Great Britain the more ancient of these rocks have been subject to so much alteration by earth movements, whereby through the effects of crushing, shearing, and re-crystallization their structure and mineral character have been greatly changed. Granite has thus become gneiss, and dolerite (one of the greenstones) has become hornblende-schist. In these schistose rocks the chief mineral ingredients have been re-arranged into more or less regular layers, simulating bedding—a structure known as foliation. Many of these great masses of crystalline rock are of a complex nature and may have originated from sedimentary rocks pierced by plutonic rocks or interbedded with ancient volcanic rocks. Complex rocks comprising gneisses and various schists, such as mica schist, graphite schist, andalusite schist, &c., characterize the oldest known group, the Archæan, and are not separately distinguished as igneous or sedimentary—all are metamorphic. The latest of our igneous rocks are those of Lower Tertiary age.

The grouping adopted on the maps is one of convenience.

G. Granite consists of felspar (orthoclase), quartz, and black and white mica.

Large masses occur in Cornwall and Devon, at Lundy Island, at Mount Sorrel in Leicestershire, the Cheviot Hills, Shap and Skiddaw, the Isle of Man, Dalbeattie and south of Creetown, Arran, and in the Highlands, including Aberdeen and Peterhead.

V. Andesites, &c.

This is a group largely composed of bedded Volcanic rocks. It includes the "Green Slates and Porphyries" or Borrowdale series of the Lake District, a great mass of lavas of more or less altered andesite (felspar, with augite or hornblende, &c.), ashes and agglomerate; also the andesitic lavas of Old Red Sandstone and Carboniferous ages in the Cheviots and along the borders of the central trough of Scotland, where they form many bold moorland crags and ridges.

T. Basalt, Greenstone, &c.

In this group of Trap rocks, intrusive bosses, sills, and dykes, as well as some bedded-volcanic rocks, have been included. Nor has it been possible to separate the dark gabbros (plagioclase felspar and hornblende) of the Cuillin Hills in Skye from the granophyre (granitic rock) of the adjacent Red Hills, both rocks of plutonic character. The dykes and sills which traverse the northern counties, such as the Cleveland Dyke, and the Great Whin Sill, the interbedded bands of "toadstone" in Derbyshire, and the altered greenstones in Cornwall, of which the Penlee Stone, near Penzance, is an example, are all included under the same heading.

S. Sepentine is an altered ultra-basic igneous rock (see p. 39).

All the igneous rocks are found to shade more or less imperceptibly from the deep-seated or plutonic types such as (1) granite, (2) syenite and diorite, and (3) gabbro, which are coarsely crystalline, into the finer grained (1) elvan or quartz-porphyry and rhyolite, (2) trachyte, felsite, and andesite, (3) dolerite and basalt; and thence into the glassy types, such as (1) the pitchstone of Eigg and parts of Arran—the differences being due to the effects of more and more rapid cooling.

The rocks (1) represent the *Acid* type, having over 65 per cent. of silica, (2) the *Intermediate* type, having 65 to 55 per cent. of silica, and (3) the *Basic*, with 55 to 45 per cent. of silica. The plutonic rocks were consolidated at a depth, having been intruded among the rocks as bosses, dykes, sills and lenticular masses (laccolites), and subsequently revealed by denudation; but the plutonic rocks merge into the volcanic which, although partially intrusive, were erupted to the surface aslavas and ashes, with often much agglomerate.

SEDIMENTARY AND METAMORPHIC ROCKS.

27. Archæan (Pre-Cambrian) and Metamorphic. 27a. Torridonian.

The most ancient rocks which form the "Foundation Stones of the Earth's Crust," and which through disturbances in that crust and the effects of vast and prolonged erosion appear at the surface over considerable areas in Great Britain, are a complex group comprising gneiss and various schists, with some definite slaty beds and sandstones, limestones and volcanic rocks. They have for the most part been highly altered not only by intrusive igneous rocks, but more especially by prodigious earth movements whereby the rocks have been folded and crushed, cleaved and sheared, faulted and overthrust, so that older sometimes appear above newer rocks. Thus gneisses and other crystalline schists have originated from the shearing and foliation of granitic and other plutonic rocks, and some schists are due to similar effects on groups of igneous and sedimentary rocks, or of volcanic ashes and lavas. (See p. 14.) Some of the earliest sandstones, such as the Torridonian, are composed largely of broken up granitic rocks (arkose), and of sands the characters of which do not differ materially from deposits of recent age. No fossils excepting possible worm burrows have been found in these sedimentary strata, and for the most part the rocks have been subjected to so many stresses and to chemical as well as mechanical deformation, that organic remains if formerly present in the sandstones or limestones have been dissolved away or obliterated by crushing.

Gneiss forms the mass of the Outer Hebrides and portions of the north-west Highlands of Scotland, it forms the core of the Malvern Hills, and appears at Primrose Hill in Shropshire. The schists occupy the main portion of the Grampians or central Scottish Highlands; other rocks, largely volcanic, appear near St. David's (Pebidian), in Charnwood Forest, in the Lower Lickey (Barnt Green series), at Caldecote near Nuneaton, and in the Wrekin (Uriconian).

The Torridon sandstone, with some slaty beds, occupies much of the coast of the north-west Highlands. The oldest rocks of the Longmynd may belong to the same era.

All these rocks form rough mountainous and heathery country, but the sandstone scenery arising from the effects of erosion on rocks more uniform in texture and more prominently jointed, has many rugged scarps and clefts and terraced slopes.

26. Cambrian. Fossils: Plate 35.

This, the most ancient system of fossiliferous rocks, comprises slates, flags and sandstones with some limestones, formed under marine conditions. Marine plants and nearly all classes of invertebrata are represented excepting corals and insects. The more noteworthy are the brachiopods (*Kutorgina*, *Obolella*, *Lingulella*), and the trilobites (*Olenellus*, *Paradoxides*, *Olenus*). The trilobites indeed appear to have been the Lords of the Creation, *Paradoxides* found near St. David's, being sometimes nearly two feet in length.

Among the rocks are the Harlech Grits and Llanberis Slates, the quartzites of the Wrekin and Hartshill, and other beds in Sutherland, slaty rocks near St. David's, the Lingula Flags of Festiniog and Dolgelly, the Malvern Shales, the Manx Slates, and part of the Skiddaw Slates.

The Tremadoc Slates, which form the highest portion, are now sometimes grouped with the Ordovician, and in this case the Durness Limestone of Sutherland would be partly Cambrian and partly Ordovician. *Orthoceras* and *Cyrtoceras* appear in these strata.

Moorland and mountain characterize much of the ground occupied by this group of rocks.

Localities for fossils: St. Davids, Tremadoc and Portmadoc, Malvern, Shineton (Shropshire), Durness (Sutherland).

25. Ordovician. Fossils : Plate 35.

In this system, again, we have a great series of marine sandstones, flags and slates, but also in the higher part important beds of limestone, and, more striking still, a great series of volcanic rocks. The forms of life are more diversified. Branched types of graptolites are found to characterize various stages in the series. Radiolaria have formed bands of chert. Bryozoa and corals appear. The trilobites include *Illænus, Ogygia, Asaphus and Trinucleus.* Brachiopods such as *Orthis* and *Strophomena,* and mollusca such as *Conularia, Pleurotomaria* (which has survived to the present day), and the cephalopod *Lituites,* appear.

The rocks of Arenig, the quartzite of the Stiper Stones (See Fig. 14), a part of the Skiddaw Slates, and the Ballantrae group of Ayrshire belong to the lower portion of the system. The Llanvirn, Llandeilo and Bala beds of Wales, with thick volcanic beds and some limestones, the Caradoc Sandstone of Shropshire, the great mass of "green slates and porphyries" (Borrowdale Volcanic series) and the Coniston Limestone of the Lake District, likewise the lower portion of the Moffat series in the Southern Uplands of Scotland, belong to the higher portion of the Ordovician.

The mountainous region of Snowdon, the moorland district of Shelve, the rougher mountains of the Lake District, the Carrick and Moorfoot Hills in South Scotland belong mainly to this group.

Localities for fossils: Haverfordwest, Llandilo, Builth, Bala, Caradoc, Shelve, Chirbury Coniston, Keisley (Westmorland), Moffat.

24. Silurian. Fossils : Plate 36.

In this system the rocks comprise a series of sandstones and shales, important beds of limestone, grits and flags, all of marine origin. Slates are not prominently developed.

The Llandovery beds and May Hill Sandstone, the Tarannon Shales, the Woolhope and Wenlock Limestones and Shales, the Denbighshire Grits, Ludlow beds and Aymestry Limestone, together with the Downton Sandstone, form the main divisions in Wales and the English border counties. In the Lake District the Stockdale Shales, Coniston Grits and Flags, Bannisdale Slates, and Kirkby Moor Flags, and in the Southern Uplands of Scotland the beds of Birkhill and Gala, Riccarton and Lesmahagow, are the divisions recognized in the Moffat district, and in parts of the Pentland Hills.

Among the fossils graptolites have proved of great importance in indicating the successive zones; they die out at the close of the era. Corals and crinoids are abundant in the limestones. The trilobites include *Encrinurus, Calymene, Phacops,* and *Homalonotus.* In the higher divisions the large crustacea, *Pterygotus* and *Eurypterus,* appear. Brachiopods are well represented by *Atrypa, Pentamerus, Spirifer,* and *Leptæna;* the mollusca include *Cardiola, Bellerophon, Euomphalus, Murchisonia, Orthoceras,* and *Trochoceras.* Among noteworthy additions to the fauna are the fishes *Auchenaspis*, *Cephalaspis*, and *Onchus*. Land-plants also are found. In the fauna of the higher divisions the Silurian is intimately linked with the Old Red Sandstone. The rocks form pleasant upland regions of moor and hill pasture.

Localities for fossils : Llandovery, Woolhope, Ludlow, Leintwardine, Malvern, Wenlock Dudley, Lesmahagow (Lanarkshire), Birkhill (Moffat District), Pentland Hills.

23. Devonian and Old Red Sandstone. Fossils : Plate 37.

In the earlier periods of which records are preserved in this country, the fossiliferous strata were marine. In Silurian times we have evidences of coral-growths and of a fairly warm temperature, with waters of no great depth. These marine conditions were perpetuated during the time when the Devonian rocks were laid down. Grouped with them is a large tract of clay-slates or "killas" in West Cornwall, at Portscatho, Falmouth and Mylor, now assigned by Mr. J. B. Hill to the Lower Palæozoic. Ordovician rocks occur at Veryan Bay, Ordovician and traces of Silurian at Gorran Haven and Porthallow. Of the Devonian, the older fossiliferous rocks are the purple and green slaty beds at Watergate Bay and Looe with fish-remains, and the grit beds near Torquay with *Homalonotus*. The former are correlated by Mr. Ussher with the Dartmouth slates.

At Plymouth, Torquay, Newton Abbot, and Chudleigh there are massive beds of limestone which yield a rich marine fauna : coral-beds with *Favosites*, *Heliolites*, and *Calceola*, numerous crinoids, brachiopods such as *Spirifer*, *Rhynchonella*, *Stringocephalus*; mollusca such as *Megalodon*, *Murchisonia*, *Clymenia*, and *Orthoceras*; and the trilobites *Bronteus* and *Phacops*. Volcanic beds, slates, and sandstones occur also, and the region is so much folded and faulted that it is difficult to separate Upper from Middle and Lower Devonian where the beds are unfossiliferous.

In North Devon a sequence has been more regularly traced, but even there the beds are violently folded, and one division, the Morte Slates, formerly regarded as Devonian, has yielded fossils of Silurian type. The Ilfracombe beds, with thin bands of limestone, are equivalent to the limestones of South Devon, while the strata at Baggy, Marwood and Pilton yield Upper Devonian Fossils, which are intimately linked with the Lower Carboniferous. In these higher beds we find the brachiopods *Spirifer disjunctus*, *S. Urei*, *Rhynchonella pleurodon*, and *Productus*, the trilobite *Phacops*, and *Entomis* (*Cypridina*).

The Devonian rocks form the high moorlands of North Devon and West Somerset, broad rounded hills with steep slopes. In South Devon the country is more cultivated, and the region of South Hams on soft slates with bands of volcanic rock, is rich agricultural land.

At Salcombe and Bolt Head, south of Kingsbridge, there is an area of highly metamorphosed micaceous slaty rocks, the age of which is a debated question.

Localities for fossils : Looe Plymouth, Torquay, Newton Abbot, Chudleigh, Watergate Bay, Bedruthan, Launceston, Ilfracombe, Combe Martin, Pilton.

The Old Red Sandstone comprises a great series of red sandstones, quartzose conglomerates, and red and mottled marls with beds of calcareous sandstone or concretionary limestone, known as "cornstones." These are regarded as indicating lacustrine, and in part estuarine conditions.

The upper beds are intimately linked with the Lower Carboniferous strata, and in some parts of the Lake District and the Scottish Borders there are basement conglomerates which may be of Upper Old Red age.

In the lower beds the fossils comprise the crustacea *Pterygotus* and *Stylonurus*, and the fishes *Pterichthys*, *Pteraspis* and *Cephalaspis*; the higher beds yield *Asterolepis*, *Bothriolepis* and *Holoptychius*.

The strata have a wide range in South Wales and the western borders of England, also in the Cheviot Hills and the lowlands of central Scotland, where great masses of volcanic rock (andesite, &c.) are present.

The rocks extend from Loch Lomond to Stonehaven, fringe the Moray Firth, and occupy much of Caithness and the Orkney Islands.

The ground is of varying character, mountainous in parts of Carmarthenshire and Brecknockshire, elsewhere on the Welsh and English borders a land of pasture and orchards. High moorlands characterize the Cheviot country, the Ochil and Sidlaw Hills; and moor and mountain prevail in northern Scotland, with good arable land near Elgin and in the Black Isle of Cromarty.

Localities for fossils: Leominster, Rowlestone (Herefordshire), Farlow (Shropshire), Dura Den (Fifeshire), Forfar, Cromarty, Elgin, Thurso, Orkney.

22. Carboniferous Limestone. 21. Yoredale Rocks. Fossils: Plate 38.

The Carboniferous system embraces a great group of coal-bearing strata, of limestones, sandstones, shales, with seams of coal and bands of ironstone, and with evidence of volcanic action in Devonshire, as at Brent Tor, also in Derbyshire, and in the Scottish lowlands. All conditions are indicated in the system, from purely marine to estuarine, freshwater, and terrestrial.

In the West of England and Wales, and in the midland counties of Leicestershire and Derbyshire, the lower portion of the system is chiefly "Mountain Limestone" in massive beds, which form the fine inland cliffs of Cheddar, the Gorge of the Avon below Bristol, the sea cliffs of Gower and Tenby, and the picturesque dales of Derbyshire. The rocks contain many corals, crinoids, bryozoa, brachiopods, as well as trilobites, fish remains, &c. (see Table, p. 1).

The Carboniferous or Mountain Limestone is locally underlain by the Lower Limestone Shales, and overlain by the Upper Limestone Shales or Yoredale Rocks (represented by the Pendleside group in Lancashire), which contain bands of radiolarian chert. From Derbyshire northwards the distinction between the Carboniferous Limestone (and associated shales) and the Yoredale Rocks becomes lost, and we have a Carboniferous Limestone series, which forms a region of high moorlands and fells, with many a "scar" of limestone. Moreover, shales, sandstones, and layers of coal are found at various horizons, the coal-seams becoming more important as we proceed through Northumberland into Scotland.

The limestone regions are for the most part picturesque craggy lands with fresh and sweet herbage, but with few surface streams except in the low lands or in Drift covered areas. They furnish dry healthy uplands, with much bare and weathered rock, and in places open joints, swallet-holes and many caverns.

Localities for fossils: Clifton (Gloucestershire), Gower (Glamorganshire), Castleton, &c. (Derbyshire), Wensleydale, &c. (Yorkshire), Lancaster, Poolvash (Isle of Man), Burntisland, &c. (Fifeshire).

20. Millstone Grit. Fossils: Plate 38.

In the West of England and Wales this is often a hard and compact siliceous rock, with subordinate bands of shale, but it includes in midland and northern areas a great series of flags and sandstones and coarse grits with quartz pebbles, as well as shales, and occasional seams of coal. In the West of England and South Wales it is known as the "Farewell Rock," as it forms the foundation of the productive Coal-measures. It yields the silica-stone for fire-bricks at Dinas in the Neath Valley, and many building and paving stones in Yorkshire and Lancashire.

As a rule it forms high moorland regions, including many famous health resorts, with picturesque crags as at Ilkley and the Brimham Rocks near Pateley Bridge.

The sandstone rocks hold a good deal of water, and the rainfall and springs of the moorlands are utilized for many a reservoir.

Fossils are not especially numerous.

19. Coal Measures. Fossils: Plate 38.

The productive Coal-measures occupy a number of basins, the result of disturbance and erosion, in Glamorganshire and Pembrokeshire, the Forest of Dean, Bristol and Somerset, and other tracts in the Midlands, North Wales, the northern counties, and the Lowlands of Scotland. The strata consist of shales, sandstones, with seams of coal and bands of ironstone. In the Lower Coal-measures of Lancashire there are hard siliceous beds known as Gannister.

The scenery is varied: as a rule, the ground is hilly and somewhat barren though well-wooded in places. In South Wales much of the coal-field is an elevated table-land formed of the central division of hard sandstones known as the Pennant Grit, with deep and picturesque valleys, along the borders of which the coal has been worked in many places by means of levels. In the smelting region of Landore by Swansea, the scene is black and dreary. In Somerset, where the Coal-measures are largely concealed by New Red rocks and Lias, we find fertile pastures and arable land intermixed with the mining tracts. In South Staffordshire the furnaces and factories have produced the desolate "Black Country," while in North Staffordshire the charms of the natural scenery are locally effaced by "the Potteries." Here as elsewhere, in Lancashire, Derbyshire and Yorkshire, in Durham and Northumberland, in West Cumberland, in the Glasgow-Edinburgh coal-fields, large centres of population have grown in connection with the mining and manufactures. Conspicuous artifical hills have in many parts been introduced by the great tips of waste material, shale and sandstone, from the coal-mines. The water from the Coal-measures is not usually good, and in the Somerset coal-field it is occasionally saline.

The leading fossils of the Coal-measures are noted in the Table, p. 1, and in Plate 38. The plants include club-mosses, horse-tails, and fern-cycads.

Localities for fossils: Radstock (Somerset), Coalbrookdale (Shropshire), Stoke-upon-Trent (North Staffordshire), and other coal-fields.

18. Permian: Sandstone and Conglomerate. 17. Magnesian Limestone. Fossils : Plate 39.

This group of red conglomerates and sandstones, with clays and marls and some volcanic rocks in South Devon, is grouped as Permian.

Certain breccias in the Midland Counties, formed of angular and partially rolled scree material, are also regarded as Permian, as well as the older red rocks, conglomerate (brockram) and Penrith Sandstone of the Vale of Eden.

The chief rocks of this age are the beds of Magnesian Limestone which form an important belt from Nottingham to North Shields and Tynemouth, and yield much valuable building-stone.

The beds yield Labyrinthodont remains, fish remains such as *Palæoniscus* and *Platysomus*, the brachiopods *Productus*, *Strophalosia*, *Athyris*, &c., and the mollusca *Schizodus* and *Bakevellia*. The fossils serve to connect the Palæozoic with the Mesozoic eras. They indicate inland-sea conditions.

Some of the granite masses, as in Devon and Cornwall, and the lavas near Exeter, are probably of Permian age.

The Permian red sandstones and conglomerates form picturesque hilly ground with deep combes near Torquay, Teignmouth and Dawlish, a dry healthy country, much cultivated, with red fields, and deep red lanes. The Magnesian Limestone is largely under cultivation. The waters are hard.

Localities for fossils: Doncaster, Brodsworth, Cadeby (Yorkshire), Marsden, Ferry Hill and Fulwell (Durham).

16. Lower Trias: Bunter Sandstone and Pebble-beds.

This group, composed of red sandstones, red loamy sands and pebble-beds, is recognized in the cliffs of Budleigh Salterton in Devon and inland in part of West Somerset. It extends over large areas in the Midland Counties forming dry healthy and picturesque sites, as near Sutton Coldfield, on Cannock Chase and Sherwood Forest. It occurs also in the Vale of Eden, and at St. Bees.

15. Upper Trias: Rhætic Beds, Keuper Marls and Sandstone. Fossils : Plate 39.

The sandstones at the base of the Keuper occur at Sidmouth and form a pleasant, dry and hilly country with many a deep red lane, in the district which extends northwards to Wellington and Williton in West Somerset. They occur at St. Anne's by Bristol, near

Malvern, in many parts of the Midland Counties, in Nottinghamshire, Derbyshire, Cheshire, and near Carlisle.

Triassic Sandstones occur in Arran, also at Dumfries and Elgin.

Localities for fossils: As a rule organic remains are few—they are mostly of Labyrinthodonts and Reptiles; Elgin, Storeton Hill near Birkenhead, Runcorn, Grinshill, Warwick, and Sidmouth, have yielded remains.

Both Bunter and Keuper Sandstones yield plentiful supplies of water, but occasionally those in the Keuper are found to be strongly saline.

The Keuper Marls which contain thin beds of sandstone, veins and nodules of gypsum, and impersistent beds of rock salt, extend, with some interruptions, across the country from Axmouth and Sidmouth to the mouth of the Tees. They form vales of undulating red ground in the south and west of England, the Vale of Taunton, and to the east of the Malvern range, regions where there is much rich pasture and orchard land. In the Midland Counties the character of the ground is modified by drift deposits.

Much of the land is of a clayey nature and the strata are not water bearing, except where the included bands of sandstone, as near Leicester, are locally of sufficient thickness to hold a supply.

The Bunter and Keuper indicate inland sea and desert conditions, with much wind-drifted material.

The Rhætic beds follow the upper limit of the Keuper Marls, and comprise grey marls, black shales, and locally White Lias, of no great thickness. They form low escarpments to the east of Taunton, in the Polden Hills of Sedgemoor, and elsewhere.

The fossils link the Keuper with the Lower Lias, and indicate the incoming of marine conditions, the fishes having Triassic affinities, while some of the mollusca extend into the Lias. *Avicula contorta* is characteristic, and among other fossils are *Cardium Rhæticum*, *Pecten valoniensis*, and *Myophoria postera*. Teeth of *Microlestes*, the oldest British mammal, have been found in this formation.

Localities for fossils: Axmouth, Watchet (Somerset), Aust and Westbury-on-Severn (Gloucestershire), Penarth (Glamorganshire).

14. Lias. Fossils: Plates 39 and 40.

This is a great group of marine clays and limestones with important local beds of ironstone.

The Lower Lias is formed of a mass of limestones alternating with clays or shales (Blue Lias), overlain by clays and shales. These beds occur at Lyme Regis and extend to the Yorkshire coast near Redcar. They occur also in Glamorganshire, at Broadford in Skye and elsewhere in the north of Scotland. At Frodingham in Lincolnshire there are beds of iron-ore.

The Middle Lias consists in its lower part of sandy beds and shales, and in its upper part of hard iron-shot limestone (Marlstone) which passes into a valuable iron-ore in parts of Oxfordshire, Leicestershire, Lincolnshire, and Yorkshire (Cleveland Hills). Elsewhere, as on Edge Hill, a useful building-stone is obtained. This rock-bed contains *Rhynchonella tetrahedra* and *Terebratula punctata.*

The Upper Lias, mainly clay, extends, like the other groups, from Dorsetshire to Yorkshire and the Inner Hebrides.

The fossils of the Lias are numerous and varied, notably the Ammonites, which characterize various stages. In the Lower Lias (Plate 39) we find in upward succession *A. planorbis*, *A. angulatus*, *A. Bucklandi*, *A. semicostatus*, *A. oxynotus*, *A. armatus*, *A. jamesoni*, and *A. capricornus;* in the Middle Lias, *A. margaritatus* and *A. spinatus;* and in the Upper Lias, *A. annulatus*, *A. serpentinus*, *A. bifrons*, and *A. communis*. *A. heterophyllus* and *Leda ovum* also occur in the Upper Lias (Plate 40).

The huge reptiles *Ichthyosaurus* and *Plesiosaurus*, many fishes and crustacea, brachiopods, corals, and other fossils are met with.

The Lower Lias limestones and the Marlstone form scarps overlooking vales in the softer clays, mostly pasture land. The harder rocks are water-bearing, the Marlstone more especially where well developed, as in Northamptonshire, but the waters of the Lower Lias are seldom copious, and often impregnated with sulphuretted hydrogen. The Middle Lias forms picturesque hilly tracts, with many orchards, in Dorset, Somerset, and Gloucestershire.

Localities for fossils: Lower Lias; Lyme Regis, Watchet, Street, Shepton Mallet, Keynsham, Bridgend, Rugby, Barrow-on-Soar, Robin Hood's Bay, Broadford (Skye), Raasay, Pabba.

Middle Lias; Golden Cap, near Charmouth (Dorset), Yeovil, Ilminster, Glastonbury, Banbury, Grantham, Yorkshire.

Upper Lias; Yeovil, Ilminster, Dumbleton (Gloucestershire), Northampton, Lincoln, Whitby.

13. Lower Oolite. Fossils: Plates 40 and 41.

The Oolites form a series of stonebrash hills and clay vales which extend from Dorsetshire and Wiltshire to Lincolnshire and Yorkshire. The rocks are all more or less fossiliferous. The limestones and sands form water-bearing strata.

The group under consideration includes the Inferior Oolite series, the Great Oolite series, and the Cornbrash, in which marine conditions prevailed in the south and west of England, while estuarine conditions are met with in some of the strata in the Midland Counties, in Yorkshire, and the north of Scotland.

The Inferior Oolite series, comprising sands with overlying limestones, extends from Burton Bradstock and Bridport to Yeovil, Bath, Dundry, and the Cotteswold Hills, forming dry healthy uplands, for the most part under cultivation. Some beds are rich in Ammonites, such as *A. opalinus*, *A. murchisonæ*, *A. humphriesianus*, and *A. Parkinsoni;* also brachiopods; and local coral-beds are met with in the Cotteswold Hills (see Plate 40). Famous freestones also occur at intervals. East of the Cotteswolds the series is represented in part by the Northampton sands and ironstone, and in Lincolnshire by the Lincolnshire limestone, together with local estuarine beds. In Yorkshire the strata are largely of an estuarine character with beds of lignite. In Skye and Raasay brown and white sandstones prevail.

The Great Oolite series comprises the Fuller's Earth (or Fullonian), the Great Oolite, and the Forest Marble. The Fuller's Earth extends from Dorsetshire to Gloucestershire, and is a mass of grey clay or marl with bands of soft limestone and occasional beds of economic fuller's earth near Bath. The clay beds form pasture lands in vales or on the slopes of escarpments. The Great Oolite appears near Bradford-on-Avon, and extends in a series of dry elevated tracts along the Cotteswold Hills to near Minchinhampton. It yields the famous Bath freestone. The overlying Forest Marble is a very variable group—the base near Bradford-on-Avon, and also in Dorset and in parts of Gloucestershire, is a fossiliferous layer known as the Bradford Clay. Here *Avicula costata*, *Terebratula coarctata*, *Waldheimia digona*, *Apiocrinus Parkinsoni*, and *Acrosalenia spinosa* may be found. Higher up the formation comprises slabs of shelly limestone and oolite, together with clays and shales and sometimes beds of sand and sandstone, yielding a very mixed soil. At the base of the Great Oolite in parts of Gloucestershire, and more especially at Stonesfield in Oxfordshire, there are flaggy beds of sandy and oolitic limestone, which have long been worked for roofing, and are known as Stonesfield Slate. These beds have yielded mammalian remains, such as *Stereognathus* and *Phascolotherium*, remains of turtles and other reptiles, fishes, and many mollusca, plants, &c.

In Oxfordshire we lose the Fuller's Earth formation, and its place is taken by coloured clays and sands known as the Upper Estuarine series. The Great Oolite becomes a white marly limestone, and the Forest Marble contains few hard stone bands, and passes into the Great Oolite Clay made up of coloured clays and sands. This series extends through Bedfordshire and Northamptonshire into Lincolnshire. In Yorkshire the only representative appears to be the Upper Estuarine series, which no doubt embraces a longer period of time than the Upper Estuarine series of the Midland Counties. In Skye the Loch Staffin series represents beds of Great Oolite age.

The Cornbrash is a rubbly limestone usually with many fossils, especially bivalve mollusca, and brachiopods. The principal ammonite is *A. macrocephalus*. Among other fossils are *Avicula echinata*, *Myacites decurtatus*, *Ostrea flabelloides*, *Pecten vagans*, *Pholadomya lyrata*, *Waldheimia lagenalis*, *W. obovata*, and *Echinobrissus clunicularis*. The formation extends from near Weymouth to the Yorkshire coast.

Localities for fossils: Inferior Oolite; Burton Bradstock, Bridport, Bradford Abbas, Sherborne, Dundry, Cheltenham, Northampton, Blea Wyke (Yorkshire), Skye.

Fuller's Earth; Eype (Dorset), Milborne Port, Shepton Montague, Bath.

Great Oolite; Bath, Minchinhampton, Stonesfield, Northampton, Bedford.

Forest Marble; Eype and Langton Herring (Dorset), Bradford-on-Avon, Malmesbury, Cirencester.

Cornbrash; Radipole near Weymouth, Closeworth, Wincanton, Trowbridge, Chippenham, Cirencester, Fairford, Witney, Rushden (Northamptonshire), Peterborough.

12. Middle Oolite. Fossils: Plate 42.

In this division are included the Oxford Clay and Kellaways beds, and the Corallian.

The Oxford Clay comprises a mass of stiff clay with septarian nodules, and shales; and at the base beds of shelly calcareous sandstone, spheroidal masses or "doggers" of sandstone, sands, and loams known as the Kellaways beds, from Kellaways, in Wiltshire. The formation has yielded many fossils—large saurians, fishes, also mollusca, especially *Ammonites modiolaris*, *A. calloviensis*, *A. jason*, *A. Lamberti*, *A. cordatus*, *Belemnites Oweni*, *Gryphæa dilatata*, and crustacea. The strata were formed under marine conditions.

They extend in a series of vales from Weymouth through Wiltshire to Bedfordshire, Lincolnshire, and Yorkshire, and they occur also at Uig, in Skye.

Localities for fossils: Weymouth, Chippenham, Oxford, St. Neots, Peterborough, Hackness (Yorkshire).

The Corallian formation comprises a series of marine oolitic limestones, marls, coral rag, calcareous sandstones or "grits" and sands. It extends from the neighbourhood of Weymouth to that of Oxford, and thence, with the exception of the limestone of Upware near Ely, the formation is represented mainly by clays (Ampthill clay) in its extension to Lincolnshire. In Yorkshire the stone-beds are again well developed in the Tabular hills west of Scarborough.

The fossils of this formation include many corals such as *Isastræa*, *Thamnastræa*, and *Thecosmilia*; echinoderms such as *Cidaris*, *Hemicidaris*; and mollusca including *Ammonites perarmatus*, *A. plicatilis*, *Bourguetia* (*Phasianella*) *striata*, *Chemnitzia heddingtonensis*, &c.

The strata form a scarp between the vales of Oxford and Kimeridge Clays, as at Sturminster Newton, in the Vale of Blackmore, at Wootton Bassett, and in Yorkshire where they form a scarp on the north side of the Vale of Pickering. Again, on Clyne Hill near Brora the beds are well shown. They form dry healthy sites. The strata are water-bearing—the water being held up by the Oxford clay.

Localities for fossils: Weymouth, Steeple Ashton, Calne, Marcham near Abingdon, Oxford, Upware (Cambridgeshire), Filey, Malton, Brora (Sutherlandshire).

11. Upper Oolite. Fossils: Plate 43.

The highest portion of the Oolitic series includes the Kimeridge Clay and Portland beds, and with them the Purbeck beds are often grouped.

The Kimeridge Clay comprises beds of dark shale with numerous bands of cement-stone and septarian nodules. The shale is frequently bituminous, and at Kimeridge in Dorset it has been utilized for the preparation of mineral oils, while one layer known as Kimeridge coal has been used locally as fuel. Highly bituminous shale occurs in Lincolnshire and also in Sussex, as proved by the Sub-Wealden boring (see p. 73).

Large saurians, fishes, many mollusca such as *Ammonites alternans*, *A. biplex*, *Ostrea deltoidea*, *Exogyra virgula*, *Rhynchonella inconstans*, and other fossils, are met with. The conditions were marine.

Like the Oxford Clay this forms a series of vales—rich pasture lands in places with many dairy farms in Dorset and Wiltshire, while the famous Vale of Aylesbury is largely composed of it.

Localities for fossils: Kimeridge, Ringstead Bay, Swindon, Shotover Hill, Ely, Market Rasen, Vale of Pickering, Helmsdale (Sutherlandshire).

In the Portland beds we have a variable series of oolitic and chalky limestones with beds of chert, calcareous sandstones and sands, and occasional beds of clay as at Swindon and Hartwell, all exhibiting marine conditions.

The beds yield many fossils notably the huge *Ammonites giganteus*, *Cerithium portlandicum*, *Cardium dissimile*, *Trigonia gibbosa*, *T. incurva*, *Lucina portlandica*, *Pecten lamellosus*, and the coral *Isastræa oblonga*.

They form the rugged cliffs from Durlston Head to St. Alban's Head and the headlands near Lulworth, the mass of the Isle of Portland with its quarries of oolitic freestone, and they are seen in quarries at Upway near Weymouth.

They reappear at Tisbury and Chilmark in the Vale of Wardour, where the freestone is a calcareous sandstone; again at Swindon there are large quarries whence hard sandstone is extracted; and outlying masses extend to near Oxford and Aylesbury.

The strata afford many dry healthy sites. They are water-bearing, the water being upheld by the Kimeridge Clay or at higher levels where local bands of clay are present.

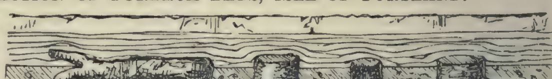
Localities for fossils : Portland, Upway, Tisbury and Chilmark, Swindon, Aylesbury.

10. Purbeck Beds. Fossils: Plate 43.

These strata consist of a mass of shelly limestones and clays, shales or marls, with occasional sandy layers. The famous Purbeck Marble formed largely of shells of *Paludina*, occurs in the upper part at Swanage. The building stone of Swanage occurs at a lower horizon and is mined extensively. Gypsum locally occurs near Swanage and it was proved in the Purbeck beds near Battle in Sussex.

The strata follow the outcrop of the Portland beds in Dorset, in the Vale of Wardour, at Swindon and onwards to Aylesbury.

FIG. 6.—SECTION OF PURBECK BEDS, ISLE OF PORTLAND.



The fossils are largely freshwater and estuarine, but there are some marine forms; they include mollusca such as *Paludina*, *Cyrena*, *Unio*, *Ostrea* and *Trigonia ;* also many insects, ostracods, the isopod *Archæoniscus*, fishes, crocodiles and turtles; and mammals such as *Spalacotherium* and *Plagiaulax*. Silicified remains of Cycads, including the so-called "Bird's nest," *Mantellia nidiformis ;* and coniferous trees, are especially noteworthy in the "Great Dirt Bed" of Portland (see Fig. 6). The strata occupy but limited tracts in the country. They extend along the higher ground bordering the coast from Swanage to near St. Alban's Head, and on the coast near Lulworth, where the picturesque coves have been hollowed out of the softer Purbeck strata after the sea had broken through the protecting Portland strata.

Localities for fossils : Swanage, Lulworth, Teffont Evias near Tisbury, Swindon.

9. Wealden: Weald Clay. 9a. Hastings Beds. Fossils: Plate 43.

This comprises two great groups, the lower, termed the Hastings beds, embraces a series of freshwater sands and sandstones with subordinate clays. They form the elevated tract in the Weald at Tunbridge Wells, Crowborough and Ashdown Forest, Mayfield and Heathfield, and the cliffs near Hastings. Picturesque wooded and cultivated areas, which furnish charming residential sites, characterize this region. The sands are locally hardened and masses weathered by rain, frost and winds form the well-known Toad Rock, the Eridge and High Rocks, near Tunbridge Wells. The clays in this lower series (Wadhurst Clay) yielded much iron-ore in old times, having been worked from the reign of Henry III. until the last furnace at Ashburnham was extinguished in 1828 (see p. 73).

The upper division is mainly clay with occasional sandy layers and bands of Sussex Marble with *Paludina*. It forms the great vale below the Lower Greensand scarp of Leith Hill and Hind Head, extending to the north, west and south of the central dome of Ashdown Forest (see Fig. 4).

Wealden beds undivided, and comprising alternations of coloured clays and sands, occur on the south of the Isle of Wight, and also fringe the bay north of Swanage and some of the coves near Lulworth.

Localities for fossils: Fossils are not very abundant if we except the cyprides which occur in the Wealden shales. Bones of *Iguanodon* have been obtained in the region of Tilgate Forest, and in the Isle of Wight. Plant-remains, including *Endogenites erosa* (*Tempskya Schimperi*), occur in places.

8. Lower Greensand. Fossils: Plate 44.

This formation, essentially a marine sandy group, presents varied characters in different areas. In the south-east of England it fringes the great Wealden area, having a base of Atherfield clay, overlain by the Hythe beds, alternations of hard Kentish Rag (cherty limestone) and "hassock" largely quarried near Maidstone. These beds are overlain by the Sandgate beds—clayey beds with fuller's earth at Nutfield. Higher still are the Folkestone beds, white and sometimes coloured sands with indurated masses; the white sands being extensively dug for glass making and other purposes near Aylesford, Godstone and other places.

In mass the strata form some of the more picturesque regions in the South of England—a land of gorse-covered heathery commons and pine-woods, including the well-known heights of Leith Hill and Hind Head, and the country near Midhurst, Petworth, Fittleworth, and Pulborough.

In the Isle of Wight again we have the pleasant country around Sandown, and the cliffs and chines of Shanklin, Blackgang, &c.

The sponge-gravels of Faringdon in Berkshire, the iron-sands of Shotover near Oxford, the glass sands of Hartwell near Aylesbury, the various sands at Leighton Buzzard, and the sands and fuller's earth beds of Woburn, all belong to this series. The high grounds are everywhere healthy sites, notably the Woburn Hills, which extend to Ampthill and onwards into Cambridgeshire. In Norfolk the sands of Sandringham, the brick clays of Snettisham, and the carstone of Hunstanton belong to this series.

In Lincolnshire there is again a varied series beginning in the Spilsby sandstone (probably of Upper Oolitic age) and extending through the clays and limestone of Tealby to the carstone which forms the highest bed. In Yorkshire the Speeton Clay is partly of Wealden and partly of Lower Greensand age.

The fossils of the Lower Greensand are varied in character and in distribution. Iguandon remains occur near Maidstone. Among other fossils are *Ammonites Deshayesi*, *Gervillia*, *Trigonia*, &c., and in the Atherfield Clay *Perna Mulleti* and *Exogyra sinuata*. In Lincolnshire and Yorkshire *Ammonites noricus*, *Belemnites lateralis*, *Pecten cinctus*, and other fossils are found.

Localities for fossils: Hythe, Maidstone, Nutfield, Sandown and Atherfield (I. of Wight), Faringdon, Leighton Buzzard, Potton, Tealby, Speeton.

7. Upper Greensand and Gault (Selbornian). Fossils : Plate 44.

These formations are grouped together as they are phases of one period. In some areas, as at Burham in Kent, they consist wholly of clay, in Devonshire almost wholly of chert beds and sand, while in parts of Norfolk, Lincolnshire and Yorkshire they are represented by Red Chalk. In all cases they are marine deposits.

Over much of the south of England, however, the higher beds are of Upper Greensand character and the lower of Gault clay. Upper Greensand thus fringes the Chalk escarpment—being quarried for firestone and hearthstone near Godstone and Betchworth. Generally it overlooks a vale in the Gault clay which is worked for bricks in many places.

The beds are well developed near Selborne and other parts of Hampshire, in the Isle of Wight, on the Blackdown and Haldon Hills in Devonshire and near Lyme Regis, at Shaftesbury, the Vale of Wardour, Warminster, Devizes and onwards to Wantage and the base of the Chiltern Hills to near Tring.

The fossils of the Blackdown Hills and Haldon are wholly replaced by chalcedony—echinoderms and mollusca are thus well preserved. Warminster has been a noted locality for sponges.

The Gault clay is well seen in the cliffs of East Wear Bay, Folkestone, a noted locality for fossils. In the Isle of Wight it forms the "Blue Slipper" at Ventnor, the foundation over which Upper Greensand and Chalk have subsided and produced the picturesque landslip or Undercliff.

Among the Gault fossils are ammonites, *A. interruptus*, *A. lautus*, *A. inflatus*, *Belemnites minimus*, *Nucula*, *Inoceramus*; also crustacea, &c. The Upper Greensand yields *Exogyra conica*, *Pecten asper*, *Pectunculus umbonatus*, and many brachiopods, echinoderms, sponges, &c.

Localities for fossils: Folkestone, Burham, Merstham, Isle of Wight, Blackdown and Haldon Hills, Warminster, Hunstanton, Speeton.

6. Chalk. Fossils : Plate 45.

This great formation consists of white limestone with layers of nodular flint, and bands and veins of tabular flint, which as a rule are more prominent in the upper portions. The entire formation is marine, largely of organic origin, and formed in a deep ocean. The lowest division or Chalk marl is in many places found suitable for the manufacture of Portland Cement. Elsewhere, as along the Medway above Rochester and near Gravesend and Grays, higher beds of Chalk are used for this purpose when mixed with river mud. Extensive levels or tunnels have been driven into the Chalk for the sake of working it without removing the overlying strata, as at Chiselhurst, Norwich, Beer, and other places.

The Chalk from its general uniformity forms smooth rolling downs —the North and South Downs, Salisbury Plain and the Dorsetshire heights, the Chiltern Hills and Royston Downs, and the Wolds of Lincolnshire and Yorkshire.

Numerous fossils are to be obtained, though not as a rule in great profusion except locally, as in the basement bed of Chloritic marl which is well seen in many parts of Dorset and at Chard in Somerset.

The fossils vary at successive stages and the beds have been grouped, according to one characteristic and abundant form, into zones as follows :—

ZONES.

Upper Chalk	*Belemnitella mucronata* *Actinocamax quadratus* *Marsupites* *Micraster* *Holaster planus*
Middle Chalk	*Terebratulina lata* *Rhynchonella Cuvieri*
Lower Chalk	*Holaster subglobosus* *Ammonites varians*

In addition to the above, the common fossils are the echinoderms, *Echinocorys scutatus* (*Ananchytes ovatus*), *Galerites albogalerus*, *Cardiaster;* the brachiopods, *Terebratula carnea*, *T. semiglobosa;* and the mollusca, *Inoceramus*, *Pecten nitidus*, &c.

The higher beds of Chalk, as elsewhere noted (p. 11), form one of our most important sources of water-supply. The Upper and Middle Chalk are so porous that rain readily sinks below ground in the hilly regions. After long-continued rain the plane of saturation in the Chalk rises, and streams then flow at higher levels in the upland valleys. The Croydon "bourne" is a notable example.

In certain situations on the high chalk downs, especially in Sussex and Hampshire, "dew-ponds" have been formed. A shallow pit is dug, sometimes 6 feet deep; this is clayed, and water is conveyed into it. Some of these ponds retain water for extended periods. The supply is of course partly maintained by rain, but chiefly by dew.

Localities for fossils: Seaton, Ringstead Bay (Dorset), Chard, Isle of Wight, Arundel, Lewes, Margate, Rochester, Gravesend, Grays, Norwich, Bridlington.

5. Lower Eocene. Fossils: Plate 46.

This group includes the following sub-divisions :—

London Clay Oldhaven and Blackheath Beds Woolwich and Reading Beds Thanet Beds	Lower London Tertiaries.

The Thanet beds, well seen in the cliffs east of Herne Bay, consist of fine sands and clayey sands of marine origin.

Mollusca are not uncommon; they include *Cyprina Morrisi*, *Corbula regulbiensis*, *Cytherea orbicularis*, *Thracia oblata*, &c.

The Woolwich and Reading beds comprise a series of mottled clays, coloured sands, and pebble-beds—a very inconstant assemblage. Westwards in the area of the London Basin, as at Reading and in the Hampshire Basin, they are mainly freshwater, and yield plant-remains. Eastwards of London they contain freshwater and estuarine mollusca, such as *Cyrena cuneiformis*, *Potamides funatus*, *Melania inquinata*, &c. *Ostrea bellovacina* is widely distributed.

In Hertfordshire the pebble-beds are locally cemented into a hard siliceous conglomerate known as the Hertfordshire pudding-stone.

The London clay is a mass of bluish-grey marine clay which weathers brown at the surface: it contains numerous septaria, and these were formerly utilized near Harwich for the manufacture of cement. The fossils include remains of plants such as palms, many mollusca, such as *Nautilus*, *Voluta*, *Pholadomya*, *Pectunculus*, and remains of crustacea, turtles, birds and mammals, of somewhat tropical character.

The London clay forms a pleasant undulating country to the north-west of London, well-timbered, and mostly grass land—but the soil is naturally stiff. In north Middlesex and eastwards it is largely covered with drift deposits.

The Thanet beds, and locally the sandy beds of the Woolwich and Reading beds and the Oldhaven beds are water-bearing. Some of the earlier artesian wells under London drew supplies from these Lower Eocene strata.

Localities for fossils : Sheppey, Oldhaven, pn r, Chiselhurst, Bognor, Isle of Wight.

4. Upper Eocene. Fossils: Plate 47.

This comprises the Bagshot, Bracklesham and Barton beds, which exhibit marine, estuarine and freshwater conditions. In the London Basin we have a series of Upper and Lower Bagshot sands with intermediate loamy and clayey Bracklesham beds. Outliers of the Lower Bagshot sands occur in East Essex, on Highgate, Hampstead and Harrow Hills, while the mass of the strata occupies a considerable area from Chertsey and Weybridge westwards to Woking, Aldershot, Chobham, Bagshot, Ascot, and Sandhurst, and again between Reading, Newbury and Kingsclere. In the Hampshire Basin the beds occur over much of the New Forest and westwards to Wareham, and they extend in a narrow belt across the Isle of Wight from Alum Bay to near Culver Cliff. The district is characterized by many heaths, commons and pine-woods, as near Weybridge and Bagshot, and on the coast at Bournemouth, with its picturesque chines.

In Dorsetshire the beds yield the famous pipe and potters' clay shipped at Poole. Somewhat similar clays are extensively dug near Newton Abbot, and in the same district at Bovey Tracey the Bovey coal or lignite is found.

The fossils are of a tropical character. The Bracklesham beds have yielded remains of palm (*Nipadites*), nummulites, mollusca such as *Cardita planicosta*, *Cerithium giganteum*, *Voluta*, *Conus*, &c., remains of sharks, a marine serpent, turtles, and mammals. The Barton clay of Hampshire has yielded many fossils of like character, including the mollusca *Crassatella, Conus, Murex, Fusus, Voluta, Rostellaria,* &c.

Localities for fossils: Bracklesham Bay, Alum and Whitecliff Bays (Isle of Wight), Bournemouth (plant-remains), Barton, Hordle.

3. Oligocene. Fossils: Plate 48.

This group which occurs in the northern part of the Isle of Wight and on the Hampshire coast bordering the New Forest, comprises a series of freshwater and marine limestones and clays known (in ascending order) as the Headon, Osborne, Bembridge and Hamstead beds. They are richly fossiliferous, yielding freshwater, estuarine and marine forms—the mollusca including *Cytherea, Cyrena, Corbula, Limnæa, Planorbis, Bulimus, Cerithium.* Remains of mammals (*Palæotherium* and *Anoplotherium*) likewise occur.

Localities for fossils: Bembridge, Whitecliff, Colwell and Totland Bays (Isle of Wight), Hordle, Brockenhurst.

2. Pliocene: 2a. Coralline Crag. Fossils: Plate 49.

The Pliocene or Crag series is a group of shelly sands and gravels with occasional seams of clay, of marine, though shallow water origin. The lowest portion, the Coralline crag, occupies limited areas near Aldeburgh and Orford in Suffolk. It is a pale shelly sand and passes into indurated beds of calcareous sandstone, from which the shells have been for the most part dissolved away. Among the fossils are the mollusca *Astarte Omalii, Cardita senilis, Pectunculus glycimeris, Venus casina, Pecten pusio, P. Gerardii, Trophon alveolatus, Turritella incrassata;* the brachiopod *Terebratula grandis,* many bryozoa, and some echinoderms.

Localities for fossils: Orford, Aldeburgh.

The succeeding division, the Red crag, is a red shelly sand much current-bedded. It occurs at Walton-on-the-Naze and over great part of eastern Suffolk from Felixstow to Aldeburgh. At its base and also at the base of the Coralline crag is a bed with phosphatic nodules, at one time largely worked for artificial manure. Here many vertebrate remains have been found. The upper part of the Red crag beyond Aldeburgh passes into pale shelly sand and gravel, which together with newer deposits of like character are grouped as the Norwich Crag series. These beds extend from Dunwich to Norwich and Weybourn.

The fossils include the mollusca *Tellina obliqua, T. prætenuis, Mactra, Lucina borealis, Cardium edule, Cyprina islandica, Natica, Purpura, Littorina, Trophon,* &c., also remains of *Mastodon* and other mammalia, and fish remains.

Localities for fossils: Walton-on-the-Naze, Sutton near Woodbridge Felixstow, Hollesley, Butley, Dunwich, Southwold, Bramerton and Thorpe near Norwich, Weybourn.

At St. Erth in Cornwall, and in pipes of the chalk at Lenham and other places in the North Downs, remnants of Pliocene deposits have been preserved. The Cromer Forest bed forms the highest portion of the Pliocene series in England. It consists of ferruginous gravel, clayey beds, with estuarine mollusca, and black peaty layers with freshwater shells and plant-remains. It is especially noted for its fossil mammalia such as *Elephas meridionalis*, *E. antiquus*, *Hippopotamus*, *Rhinoceros etruscus*, *Trogontherium*, *Hyæna*, *Machærodus*, many remains of Deer, &c. This bed has been exposed beneath the Glacial Drift at the base of the cliffs and in places on the foreshore, at Kessingland and Corton in Suffolk, and near Cromer in Norfolk.

1. Recent and Pleistocene: Alluvial Drift; 1a. Glacial Drift. Fossils: Plate 50.

The formations previously considered have regular outcrops and are disposed in fairly regular sequence—the older for the most part in the west and north of Great Britain, and the newer in midland, south-eastern and eastern regions.

The deposits now to be described occur irregularly on any of those stratified or igneous formations, as they have been accumulated since the main features of the country were sculptured. The more extensive of these drift deposits were due mainly to the influence of ice—to local glaciers in the mountains and to widespread sheets of ice over the greater part of the country. Originating in vast accumulations of snow which were gradually converted into ice and welded to the ground, these ice-sheets moved outwards by reason of the impulse of the pressure, aided and directed locally by glacier ice from the more elevated regions. With the movements the superficial weathered strata and portions of the more solid substrata were shifted, and carried in many instances to higher levels in the ice, by the numerous shear-planes or overthrusts which are produced in masses of ice when they encounter obstacles. In this way the rubbly rock, the flints and other hard stones, were some of them shattered and crushed together, and the limestones, pieces of cement-stone and hard chalk were scored and scratched by sharp fragments. The boulder-clay due to the melting of the ice was perhaps again and again over-ridden by ice and pressedi nto the tough stony clay of which it mainly consists. Glacial deposits thus comprise stiff clay with erratic stones (boulder-clay or till), and this passes through a kind of earthy drift into sand and gravel. The boulder-clay is the more direct product of the ice agents, the sands and gravels as a rule being due to streams and floods arising from the melting of the ice.

These Glacial Drifts are not represented on the maps.

The records of this Ice Age are well marked in Scotland, the Lake District, the Northumbrian, Yorkshire and Lancashire moorlands, the Isle of Man, and Wales, where the vestiges of glacial action are to be seen in the accumulations of boulder-clay with ice-scratched stones, in the striated pavements of rock, in the rounded and polished rock-surfaces (*roches moutonnées*), the perched blocks, and transported boulders that may be easily recognized by those familiar with modern glacial action. (See Fig. 7.)

Deposits of this period are likewise spread far and wide over the Midland and Eastern Counties, burying up the more solid strata to the depth sometimes of 200 feet, and thus exercising great influence on the agricultural character of the country. Even as far south as

Finchley, and Hornchurch in Essex, the records may be traced, and in the boulder-clay a goodly collection of British fossils and rocks may be gathered—the specimens having been derived from various parts of the Midland and Northern Counties and some (indirectly perhaps) from Scandinavia. Fossils from the Cretaceous and Jurassic rocks are the most conspicuous in the boulder-clay of East Anglia which contains much chalk and flint.

The valley gravel and brickearth are deposits lying at a higher

FIG. 7.—VIEW IN THE PASS OF LLANBERIS. (*Ramsay.*)
Roche moutonnée, with perched blocks.

level than the ordinary alluvium and formed at a time when the rivers had not cut so deeply into their valleys. In the Southern and Midland Counties these deposits usually contain palæolithic implements, also remains of mammoth, rhinoceros, hippopotamus, &c., and in places *Unio littoralis, Corbicula fluminalis,* and other mollusca (freshwater and land).

The land, then, no doubt stood at a relatively lower level, as in many parts of Scotland the valley gravels pass into the newer raised beaches which fringe the coast. The older raised beaches may belong to an earlier part of the Pleistocene period, prior to the closing scenes of the Glacial episode.

The ordinary alluvium is the belt of flat land that borders the rivers and streams and would be flooded if they overflowed their banks. It is composed of silt or mud, loam, peat, and sometimes gravel.

The organic remains found in it are recent freshwater mollusca, including also animals like the wolf, bear, beaver, reindeer, elk or moose, and others which have been exterminated in historic times.

In the Thames Valley at Tilbury Docks the alluvium is nearly sixty feet thick, and a human skeleton was met with at a depth of thirty-two feet. Here and in other localities the depth of alluvium indicates the subsequent depression of the land.

Alluvial tracts form rich meadow lands and in other places marshy tracts.

The peaty areas in Engand are found in Sedgemoor in Somerset, in the Fenland, at Chat Moss and Carrington Moss on the borders of the Mersey, and in the Solway Moss on the Scottish borders. In the more mountainous districts of England, Wales, and Scotland peat occupies not only old marshy tracts in the low grounds, but there is much on the hill-sides due to the decay of heather and grasses. In Highland regions and in many of the Scottish isles the peat is extensively dug. In many cases peat and alluvium occupy the sites of old lakes.

Blown Sands occur in areas where there is an expanse of sea sand at low tide, and the wind drifts the material inland where it becomes heaped up in dunes, which sometimes rise to a height of sixty or eighty feet. In some places, as in Cornwall, much of the blown sand is largely made up of comminuted shells, elsewhere it is mainly quartz sand. Marram or sand grass is cultivated in places to protect the sand hills from drifting.

The later geological records are intimately connected with the history of man. The earlier monuments, like those of Avebury and Stonehenge, were erected from loose blocks of stone, for the most part obtained in the neighbourhood, such as the masses of sandstone known as greywethers that lie scattered about the surface of the Wiltshire Downs. A few of the blocks at Stonehenge were brought from a distance, and the greywethers were hewn into more definite shapes.

The earlier stone-implements were fashioned from large water-worn flints or other stones that were found along river-courses, in natural banks of gravel, or in the surface-soil. In later times excavations were made in the Chalk to obtain the flints from their natural position.

The construction of pit-dwellings and of dene-holes for refuge or for storing grain, the formation of camps and other earth-works, the digging of graves and sinking of wells, led to the acquirement of some knowledge of the strata beneath the surface-soil, as did also the processes of mining for gold, tin, and iron, and the digging of clay for pottery.

During the Roman occupation quarrying must have been extensively carried on for the construction of bridges, paved roads, and villas.

MINERAL PRODUCTS OF GREAT BRITAIN AND IRELAND.

ALUM.—A double sulphate of aluminium and potassium (or other base) formerly made from the alum-shale of the Upper Lias near Whitby in Yorkshire; now prepared from shales in the Yorkshire Coal-measures.

AMBER.—A fossil resin met with occasionally on the shores of Norfolk and Suffolk, and perhaps derived from Oligocene deposits beneath the North Sea, of the age of the strata on the shores of the Baltic.

AMETHYST.—Quartz crystals having a purple tinge due perhaps to the presence of manganese or iron salts.

ANTIMONY.—Sulphide of antimony (stibnite) has been obtained from veins in North Cornwall, and in the Southern Uplands of Scotland.

ARSENIC.—Obtained as a by-product from arsenical ores of iron, copper, and tin, but chiefly from arsenical pyrites (mispickel) in Cornwall and Devon.

ASBESTOS.—A thread-like variety of hornblende which occurs at Moel Hebog in N. Wales, and in serpentine at the Lizard in Cornwall, at Portsoy in Banffshire, and at Glenelg in Inverness-shire. Some asbestos is fibrous serpentine.

BARYTES.—Sulphate of barium (heavy spar) occurs in Carboniferous and older rocks in Devonshire, Shropshire, Derbyshire, Yorkshire, and Westmorland. The carbonate of barium (witherite) occurs in Northumberland, Durham, Westmorland, and the Isle of Man. Barytes is also obtained in Montgomeryshire, Renfrewshire, and in counties Cork and Sligo.

BAUXITE.—A mineral from which aluminium is obtained, as at the Falls of Foyers in Inverness-shire. The material occurs among the volcanic rocks of Antrim. It is composed of alumina and peroxide of iron.

BISMUTH.—Sulphide of bismuth (bismuthine) is found in some of the mines in Cornwall and Devon, also in Cumberland.

CAIRNGORM.—Quartz crystals, tinged yellow or brown, formed in drusy cavities of granite veins.

CARNELIANS.—Banded varieties of chalcedony tinted by peroxide of iron. Pebbles derived from Glacial Drifts are found in the beaches along the Eastern coasts from Scarborough southwards to Suffolk.

CHERT.—An impure variety of flint. It occurs in veins, irregular nodules, and layers, sometimes largely made up of radiolaria as in the Ordovician rocks of Mullion Island, Lizard, and Ayrshire. Radiolarian chert also occurs in the Lower Carboniferous rocks at Coddon Hill near Barnstaple; in the same rocks chert is found at Leyburn and other places in Yorkshire, Derbyshire, and Flintshire. In the Portland beds of Dorsetshire, and in the Upper Greensand of the Isle of Wight and western Counties, chert for the most part derived from sponge spicules is prominently developed.

CLAY.—Chiefly hydrous silicate of aluminium. The purest form, Kaolin or china clay, has been formed by the decomposition of felspar in granite, as at St. Austell in Cornwall. Less pure forms, to a large extent derived from accumulations of Kaolin, occur in the Eocene strata of Bovey Tracey and Newton Abbot in Devonshire, and Poole in Dorsetshire, where the varieties known as pipe or potters' clay are dug.

Terra cotta clay is obtained in the Permian at St. Mary Church and Torre near Torquay. Terra cotta bricks are made at Hathern in Leicestershire from Keuper marls.

Fire-clay, a refractory clay obtained from the Coal-measures at Stourbridge, Wortley near Leeds, and many other places, is employed in the manufacture of crucibles, fire-bricks, &c.

Clays for the manufacture of pottery, bricks, and tiles are found in many geological formations.

Modelling clay is obtained from the clays at Watcombe, Poole, and Stoke-on-Trent, and is prepared for use by being mixed with wax, stearine, glycerine, or oil.

COAL.—There are several varieties of coal, and almost the whole of that obtained in Britain is from Carboniferous rocks. In the Midland and South-Western Counties of England and in Wales the Coal-measures yield the coal, and this is the case in the Lancashire and Yorkshire coal-fields. Further north, the Lower Carboniferous rocks, as well as the Coal-measures, are productive, as in Northumberland and in the Scottish coal-fields. Coal of Oolitic age has been worked at Brora in Sutherlandshire, and a Tertiary brown coal or lignite has been worked at Bovey Tracey and near Chudleigh in Devonshire. Tertiary lignite also occurs in Antrim and Londonderry.

Ordinary house coal, known as "*bituminous*" *coal*, is rich in volatile hydrocarbons. It contains about 75 per cent. of carbon and passes into the varieties known as free-burning or steam-coals. These again merge into *anthracite*, which has a shining conchoidal fracture, and contains 90 to 93 per cent. of carbon, having but little volatile matter. *Culm* is a shaly variety of anthracite. *Cannel* or *parrot coal*, which contains 80 to 84 per cent. of carbon, is a hard dull coal with much volatile matter; it is used for gas-making.

The total yield of coal in tons for the past four years is as follows:—

	1901	1902	1903	1904
England	153,451,070	158,557,585	160,562,348	161,355,167
Wales	32,686,631	34,303,240	34,665,991	35,514,079
Scotland	32,796,510	34,115,309	34,992,240	35,453,389
Ireland	103,029	108,737	102,812	105,637

This is a considerable portion of the coal now annually raised throughout the world, which amounts to about 725 million tons.

COPPER.—Copper-ore is obtained chiefly from Cornwall, Devon, and Anglesey. In smaller quantities it is obtained from Carnarvon and Merioneth-shires, while Cheshire, Lancashire, Cardiganshire, Cork, and Wicklow have also yielded supplies. Copper-pyrites or chalcopyrite (sulphide of copper and iron) is the principal ore. In Anglesey the metal is obtained as 'copper precipitate,' from cupriferous waters.

DIATOMITE.—Diatomaceous deposits accumulated in lakes, in Skye, Aberdeenshire, and other parts of Scotland, have been utilized for fire-proof linings, for polishing metals, and in the preparation of dynamite. Similar deposits occur near Toome, in Antrim.

DOLOMITE.—Magnesian limestone, which occurs in the Permian formation of Nottinghamshire, Derbyshire, Yorkshire, and Durham. The rock often exhibits curious concretionary structures. The Carboniferous limestone and the Durness limestone are frequently dolomitic.

FLINT.—This occurs in nodules and veins in the Chalk, and has been worked in pits and shafts near Brandon, near Norwich, at Beer Head in Devonshire, and in Antrim, for gun-flints. It is used more extensively for road-metal and for building purposes; and also in the manufacture of porcelain and glass.

FREESTONE.—Limestone and sandstone which can readily be cut into blocks.

FLUOR SPAR.—Fluoride of calcium occurs in many localities, but more abundantly in Derbyshire, where it is worked for the manufacture of vases and other ornamental objects. "Blue John" is a purple variety from Castleton.

FIRE-STONE.—Stone capable of resisting the action of fire has been obtained from the Carboniferous and other formations.

In Surrey the Upper Greensand has yielded a rock known as fire-stone, a calcareous sandstone, some varieties of which are used for hearth-stone.

FULLER'S EARTH.—A variety of clay which, owing mainly to its physical character, is not plastic, but falls to a powder under water. It occurs in the Lower Greensand at Nutfield near Reigate and at Woburn, in the Oolitic series at Midford and Wellow near Bath, and occasionally in the Silurian rocks.

GARNETS.—A group of minerals consisting of double silicates of aluminium and iron or calcium, &c., met with in various metamorphic rocks.

GOLD.—Gold was worked by the Romans at Gogofau near Llanpumpsaint in Carmarthenshire. A varying amount has in recent years been obtained between

Dolgelly and Barmouth—in 1900, 14,000 ounces of bar gold; in 1901, 6225 oz.; in 1902 and 1903, rather less; and in 1904, 19,655 oz. In Sutherlandshire, in the Leadhills in Scotland and in County Wicklow, gold has also been obtained in small quantities.

GRAPHITE.—Plumbago or Black Lead (carbon with a small amount of iron-oxide) was formerly worked at Borrowdale in Cumberland.

GREYWETHERS.—Hard masses of sandstone, sometimes with flint-pebbles, and with purely siliceous matrix, found in the Reading beds and Bagshot beds. Blocks derived from these formations are found on the Downs of Wiltshire and elsewhere in the South-East of England, and, from their fancied resemblance to sheep, they were termed Greywethers. They are also known as Sarsen Stones.

GYPSUM.—Hydrous sulphate of lime occurs in crystalline form as selenite in many clays and other deposits. Elsewhere it occurs as semi-crystalline nodules and veins, especially in the Triassic marls of Cumberland, Westmorland, Durham, Derbyshire, Nottinghamshire, Staffordshire, Somerset, and Monaghan; and in the Purbeck beds of Sussex and Dorset. The finer granular kinds, known as Alabaster, are wrought into various ornamental articles. Plaster of Paris is prepared from calcined gypsum, and this is used in the manufacture of other cements.

IRON.—Iron-ore was formerly obtained from the Wealden strata in the South-East of England; and subsequently, when coal came to be worked, it was very largely mined in the form of clay ironstone (impure carbonate of iron) from the Coal-measures, where it occurs in nodular layers. The black band ironstone (carbonaceous ironstone) is still extensively worked in Staffordshire and Scotland.

Pisolitic ore occurs in the volcanic series of Antrim.

The chief part of our iron-ore is, however, now obtained from the Jurassic rocks as "brown iron-ore" or limonite, and earthy carbonate of iron. The ore occurs in beds in the Middle Lias of the Cleveland Hills in Yorkshire, and of Lincolnshire, Leicestershire, and Oxfordshire; in the Lower Lias of Frodingham in Lincolnshire; in the Northampton sands; and in the Corallian rocks of Westbury in Wiltshire.

Bog iron-ore is an impure limonite formed in marshes, &c.

The Carboniferous limestone of Cumberland and Lancashire, the Forest of Dean and Llantrissant in South Wales, yields the red iron-ore or hæmatite; while the Morte slates of the Brendon Hills and the Carboniferous rocks of Weardale in Durham have yielded Spathose iron-ore (carbonate of iron).

Magnetic iron-ore occurs at Hey Tor in Devonshire and at Rosedale in Yorkshire.

Iron-pyrites (bi-sulphide of iron) is valuable mainly for the manufacture of sulphuric acid and sulphate of iron. It is worked at Ovoca, in Wicklow.

JET.—Formerly obtained in considerable quantities in the Upper Lias near Whitby in Yorkshire. It is usually regarded as a compact variety of lignite.

LEAD.—Obtained chiefly from veins and cavities in the Carboniferous limestone series in Northumberland, Cumberland, Durham, Yorkshire, Derbyshire, Flintshire, Denbighshire, and from the refuse of old mine-works on the Mendip Hills.

It occurs also in the older rocks in Shropshire, Cardiganshire, at the Foxdale and Laxey Mines in the Isle of Man, in the Leadhills of the Southern Uplands of Scotland, and in County Wicklow. The more important ore is galena (sulphide of lead), which usually contains silver. Cerussite (carbonate of lead) is also of economic value.

LIGNITE.—Lignite or brown coal has been formed from vegetable matter, less mineralized than coal. It has been worked occasionally at Bovey Tracey and near Chudleigh. It there contains a good deal of iron-pyrites.

LIMESTONE.—Nearly all the limestone formations have been quarried for economic purposes. Some, like the Carboniferous limestone and the Chalk, yield a very pure lime, suitable for chemical and agricultural purposes.

Other and argillaceous varieties yield a natural hydraulic lime, such as the "Blue Lias" and the Chalk marl. Elsewhere, Chalk mixed with river-mud is largely used in the manufacture of Portland Cement, and soft white Chalk is used for whiting.

Hard and somewhat sandy beds of Chalk have been employed for building purposes as at Beer in Devonshire and Totternhoe in Bedfordshire.

Various Oolitic limestones furnish our most valuable freestones, as the Portland

Stone of Portland; the Great Oolite of Bath, Minchinhampton, and Milton near Burford in Oxfordshire; and the Inferior Oolite series at Ham Hill, Doulting, and Dundry in Somerset, at Painswick and other places on the Cotteswold Hills, at Weldon, Ketton, Casterton, Stamford, Ponton, and Ancaster in the Midland Counties and Lincolnshire.

The Magnesian limestone of Nottinghamshire, Derbyshire, and Yorkshire yields famous building-stone, as at Mansfield, Bolsover, Anston, Roche Abbey, Doncaster, &c.

Some of the harder rocks, as the Carboniferous and Devonian limestones, are extensively quarried for road-metal. They also yield marble, the Carboniferous limestone of Derbyshire and elsewhere affording many ornamental varieties, among which may be noted the shelly Hopton Wood stone, near Wirksworth, a coral limestone from Frosterley in Durham, the red marble of Cork, and the black marble of Kilkenny.

The Devonian limestone at Newton Abbot, Ipplepen, and Torquay yields many varieties of coral and other limestone, suitable for polishing. The Purbeck Marble of the neighbourhood of Swanage, formed mainly of *Paludina*, has in old times been extensively quarried. The Forest Marble, shelly limestone, has been polished for local use. The Landscape (arborescent) marble of Cotham near Bristol is utilized for the manufacture of small ornaments. In Scotland the marble of Tiree is of Archæan age, and that of Skye is Cambrian.

MANGANESE.—Not uncommon in many geological formations. Pyrolusite (binoxide of manganese) is the most abundant ore. It is worked near Llanbedr and Barmouth in Merionethshire, and has been obtained in smaller quantities in Carnarvonshire, Derbyshire, Devonshire, and Cornwall.

MARBLE.—(See under Limestone and Serpentine.)

OCHRE.—Earthy varieties of iron-oxide, obtained in various places, as in Anglesey, at Shotover Hill in Oxfordshire, Winford in Somerset. Reddle or raddle is a highly ferruginous clay.

PEAT.—An accumulation of vegetable matter, slightly mineralized, and formed in low-lying marshy areas or in pools and boggy places on moors and mountains. Near the surface peat is usually light-brown in colour, and spongy, while the plant-remains are little altered; deeper down the material is darker in colour, denser, and the plants are more decomposed. Peat is composed of Mosses, Reeds, Rushes, Sedges, Heaths, Ferns, and other plants.

PETROLEUM and OIL SHALE.—The bituminous shale of the Kimeridge clay of Dorset has at various times been worked for the production of naphtha, &c.

In Lincolnshire the clay is locally bituminous. At Heathfield in Sussex natural gas has been found in the Wealden-Purbeck strata, and has been utilized without need of any refining. From the Coal-measures of Torbane Hill in Linlithgowshire, which have yielded the famous "Bog Head Cannel," and from similar strata in Fifeshire, and at Leeswood in Flintshire, paraffin oil has been produced by distillation.

Albertite, an asphaltic variety of cannel coal, occurs in Ross-shire.

PHOSPHATES.—Nodules and phosphatized fossils containing much phosphate of lime, and in some cases true coprolites, have been obtained from the Bala beds, from the Lower Greensand, from the base of the Chalk, and from the base of the Crag in Suffolk. Phosphatic Chalk has also been found at Taplow.

ROAD STONES.—Stones of variable quality are employed locally. Better stones are more and more extensively used, as the granite of Mount Sorrel, various greenstones and other igneous rocks from Guernsey, Rowley Rag, Clee Hill (Dhu Stone), &c.; also the quartzite (Hartshill stone) of Nuneaton, and the Carboniferous limestone or so-called "Mendip Granite." Slag from iron-furnaces is locally used.

ROTTENSTONE.—A porous siliceous material due to the decomposition of cherty limestone. It is derived from the Lower Carboniferous rocks of Derbyshire, Flintshire, and South Wales, and is utilized for polishing purposes.

SALT.—Common Salt (chloride of sodium) was formerly prepared from bay-salt, which was obtained by evaporation from sea-water along many parts of the coast.

Rock Salt has been worked at Northwich in Cheshire, where two beds occur eighty to ninety feet thick, and in Lancashire, Staffordshire, and near Carrickfergus in

Antrim; but the supply is mostly procured from brine springs in Cheshire, Worcestershire, and on the borders of Durham and Yorkshire, near Middlesbrough. The material is obtained from the Triassic marls.

SANDS.—Clean quartzose sands suitable for glass-making occur in the Lower Greensand of Reigate, Godstone, Aylesford, Berstead, Hartwell, &c.; in the Headon Hill sands; and in the Carboniferous strata at Ballycastle, Antrim. Leighton Buzzard furnishes a variety of sands in the Lower Greensand—silver sand, filter sand, sand for mortar, &c. The Bagshot sands of Alum Bay are noted for their many colours.

The so-called silica clay or stone of the Vale of Neath yields the Dinas fire-bricks.

Moulding sands are largely obtained from the red loamy sands of the Bunter. The Thanet beds also furnish good foundry loam.

Bath-bricks are made from the siliceous (partly diatomaceous) silty sand of the River Parrett at Bridgwater, and were so named after the original manufacturer.

SANDSTONE.—Rocks made up of grains of quartz with often fragments of felspar, mica, &c. The matrix or cementing material may be carbonate of lime, silica, or ferruginous matter. Where the rock contains tiny pebbles or conspicuous angular fragments the term "grit" is sometimes employed. Beds of Millstone grit were originally used for millstones.

Fissile or flaggy varieties of sandstone have been extensively used for paving-stone, especially from the Coal-measures of Yorkshire, but the introduction of artificial pavement has much affected the industry there, and also in Caithness, where the Caithness Flags (Old Red sandstone) have for long been quarried.

Other varieties have been used for grindstones, as at Newcastle and Bilston, while the cherty sandstones of the Blackdown Hills have especially in old times been utilized as whetstones.

Hard sandstones suitable for building are obtained in the Millstone Grit and Coal-measures, and other Carboniferous rocks, among which are the Dean Forest stone (Pennant Grit), the Darley Dale stone near Bakewell in Derbyshire, the Bramley Fall stone near Leeds, the Craigleith stone of Edinburgh, and other rocks in Fifeshire.

The New Red (Keuper) sandstone yields a good building-stone in the Midland Counties near Nottingham and Derby, at Hollington near Uttoxeter, and at Runcorn; and New Red sandstone is quarried at Dumfries, in Arran, and at Elgin.

Red and white dolomitic sandstones of the age of the Magnesian Limestone are quarried at Mansfield Woodhouse.

Old Red sandstone yields building-stone at Cradley near Malvern, at Cupar, Elgin, and many other places.

SEPTARIA.—Nodules of argillaceous limestone or cement-stone with cracks or septa filled with carbonate of lime. These occur in the great clay formations, such as the London clay, Kimeridge clay, and Oxford clay. Those from the London clay were formerly utilized in the manufacture of "Roman" cement, and even for building-purposes in the old walls of Colchester.

SERPENTINE.—Hydrous silicate of magnesium and iron, red and green in colour, with veins of steatite or soap-stone. It occurs at the Lizard in Cornwall, near Holyhead, at Portsoy in Banffshire, and (intermixed with limestone forming ophicalcite) in Connemara, Galway; and has been polished as marble for various ornamental purposes.

SILVER.—Mainly obtained from argentiferous galena, as in Devonshire, Cardiganshire, the Isle of Man, the Leadhills, at Silvermines, Tipperary, and in County Wicklow.

SLATE.—A hard argillaceous rock which, through pressure, has been made to cleave in a direction independent of the original planes of deposition, though sometimes corresponding with them. The best slates are obtained in North Wales from quarries in the Cambrian rocks at Penrhyn and Llanberis, and they are mined in the Ordovician rocks at Festiniog. Others occur in the Devonian rocks at De la Bole and in the Carboniferous at Tracebridge near Ashbrittle in Somerset. Slates are quarried at Ballachulish and Easdale in Argyllshire, many having cubes of iron-pyrites in them. The "green slates" of Borrowdale have been used for roofing purposes. Slate pencils have been made from the Skiddaw slates.

Hone stones are hard, smooth-grained slaty or ashy rocks (usually much altered), of which the Charley Forest stone of Charnwood Forest, the Welsh oilstone, and the Water-of-Ayr stone are examples.

The so-called Stonesfield and Collyweston "slates" are in reality flagstones or tile-stones that split along the planes of bedding. The stone is raised when wet and kept damp until there is a frost, when it naturally splits into thin slabs, which are dressed for use. In the Forest Marble stone-tiles are also obtained.

STEATITE.—Soap-stone, a variety of talc found in association with serpentine.

STRONTIUM.—Obtained in the form of Celestine (sulphate of strontium) at Wickwar and Yate in Gloucestershire.

TALC.—Hydrous bisilicate of magnesium: flexible, but not elastic.

TIN.—Tin-ore occurs in veins traversing the granite and killas of Cornwall and Devon, mostly as Cassiterite or tin-stone (peroxide of tin). It has also been worked in the Cornish alluvial deposits, and "stream-tin" works were established to obtain it.

TOPAZ.—Silicate of aluminium with silico-fluoride of aluminium: occurs in Cornwall, in the Scottish Highlands, and in the Mourne Mountains.

TOURMALINE.—Borosilicates of aluminium, magnesium, iron, &c. Under the name of schorl the black variety is abundant in the granite of Cornwall and Devon.

UMBER.—Earthy oxides of iron and manganese: have been obtained in the Forest of Dean, the Isle of Man, and Anglesey.

URANIUM.—Uranium ores are worked near Grampound in Cornwall. Pitchblende (oxide of uranium, &c.), has become famous on account of the discovery in it of the new element Radium.

WOLFRAM.—This is a double tungstate of iron and manganese, and has been worked in Cornwall. It is used for making tungsten-steel, &c.

ZINC.—Calamine (carbonate of zinc) was at one time obtained from the Mendip Hills, also from Northumberland and the Leadhills.

Blende, or "Black Jack" (sulphide of zinc), is found in Cumberland, Derbyshire, Denbighshire, Cardiganshire, and Cornwall.

GEOLOGY OF THE COUNTIES OF GREAT BRITAIN.

ENGLAND.

Bedfordshire. Map 2. Area 298,494 acres.

The Chalk range of the Chiltern Hills occupies the southern part of the county, forming the Dunstable and Luton Downs, whence rise the Lea on the south and tributaries of the Ouse on the north. Freestone, suitable for inside work, has been largely quarried and mined at Totternhoe in the Lower Chalk. A vale of Gault clay extends below the Chalk escarpment, and northwards rise the Lower Greensand hills of Woburn, Aspley Guise, and Ampthill—a salubrious region largely formed of sands, with beds of fuller's earth at Woburn, and some tracts of boulder-clay. In the eastern part of this area phosphatic nodules were at one time worked in the Lower Greensand at Potton, and many phosphatized fossils were to be obtained. The sands are extensively worked near Leighton Buzzard, for filter-beds, mortar, silver-sand, &c. At this locality a bed with many brachiopods has been discovered by Mr. G. W. Lamplugh, between the Lower Greensand and Gault. The fossils have affinities with those of the Upper Greensand.

Still further north is a broad vale formed mainly of the Oxford Clay, with scattered deposits of boulder-clay and gravel, and with valley gravel yielding palæolithic implements and remains of mammoth, rhinoceros, hippopotamus, &c. In the Ivel Valley at Biggleswade, where there is much valley gravel, the district is famed for its market-gardens. Near Ampthill the Ampthill clay of Corallian age occurs between the Kimeridge and Oxford clays. The lower part of the Oxford clay—the Kellaways beds has been well exposed near Bedford, where it contains sandy beds and large doggers of calcareous sandstone. The Cornbrash is represented by a thin band of limestone, and this and the Great Oolite clays and limestones below are well shown in quarries bordering the Ouse Valley near Bedford. Large forms of *Nautilus* are met with. At Flitwick there is a spring of chalybeate water, derived from the Lower Greensand.

Berkshire. Map 3. Area 462,224 acres.

The southern part of the county is occupied by the Eocene clays and sands with cappings of Drift gravel, and with river gravel and peat along the Kennet Valley. The country is pleasantly diversified with commons, but there is an admixture of light and heavy lands. Reading gives name to the Reading beds which contain important beds of mottled plastic clay, utilized in brickworks and tile-kilns. The residential districts of Ascot and Sunninghill and the higher grounds of Windsor Forest are on Bagshot beds.

North of Newbury and Reading the Chalk gradually rises to the White Horse Hill above Wantage, and to the Chiltern Hills, which may be said to extend north-eastwards from the gorge of the Thames between Pangbourne and Goring. The Chalk occupies a syncline south of Hungerford, and rises southwards into the high down of Inkpen Beacon (1011 ft.). At Kintbury it is largely quarried for the manufacture of whiting. Eastwards the Chalk is upraised in an anticline at Windsor, and is exposed in the ice-house in the Castle grounds.

The Vale of White Horse beyond Wantage is formed partly of Gault and Kimeridge clay. Notable are the Lower Greensand pits at Faringdon, where sands and gravels full of sponge-remains and other fossils are met with. The Corallian beds form pleasant hilly tracts from near Faringdon to Abingdon, Cumnor, and Wytham Hill, and in the numerous quarries, as at Marcham, many ammonites, corals, and other fossils may be obtained.

The Oxford clay extends northwards over a broad vale traversed by the River Thames.

Buckinghamshire. Map 2. Area 475,694 acres.

This county extends from the valley of the Thames to that of the Ouse. In the southern portion the Reading beds and London clay extend from Colnbrook to Beaconsfield, and are covered in the Thames valley by gravel and brickearth, the brickearth being extensively dug for brickmaking at Langley. Northwards the ground rises and forms a plateau covered with Drift gravel. In the deeper valleys the Chalk appears, as on the borders of the Burnham Beeches, and further west at Taplow it contains phosphatic layers. The Chalk rises into fine uplands with occasional Eocene outliers, near High Wycombe, Amersham, and Chesham, and to the north-west it forms the bold escarpment of the Chiltern Hills near Princes Risborough and Wendover, rising to 852 feet at Combe Hill. This is a region famed for beech trees, and the wood is largely utilized for chair-making.

To the north-west the Gault and Kimeridge clay form the Vale of Aylesbury, a tract rendered fertile by outlying hills of Portland beds, Purbeck beds, and Lower Greensand, as at Brill, Quainton, &c., down-washes from which have ameliorated the heavy soil of the vale. There is a chalybeate spa at Dorton near Brill.

The Lower Greensand contains white and coloured sands, sometimes cemented into a hard rock. The sands at Hartwell have been used for glass-making. Coprolites (phosphatic nodules) were at one time worked at Brickhill, and they have also been worked in the Gault at Towersey.

Hartwell is a famous locality for fossils, as there are quarries in Portland stone, with large ammonites, &c., and other specimens may be obtained from clay pits in the Hartwell clay (Lower Portland) which overlies the Kimeridge clay. Further north a broad clay tract, much covered with boulder-drift, extends from Bletchley, by Winslow and Whaddon Chase to Marsh Gibbon—a famous hunting ground. At Buckingham, Stony Stratford, Newport Pagnell, and Olney the Lower Oolites appear. They may be observed in quarries bordering the Ouse Valley, but the plateau, as at Stowe Park, is largely covered with boulder-clay.

Cambridgeshire. Map 4. Area 549,749 acres.

The southern part of the county is formed of Chalk which occupies the higher grounds from Royston on the Essex borders to Great Chesterford, Linton, the Gogmagog Hills (300 feet), and the neighbourhood of Newmarket.

The lower beds of Chalk marl are largely quarried for cement-making at Shepreth; while the basement bed, with many phosphatic nodules and fossils, known as the "Cambridge Greensand" was extensively worked for "coprolites" near Cambridge, and also at Soham and other places. Higher up a band of freestone, known as Totternhoe stone, has been dug at Burwell and Cherry Hinton, together with overlying beds of Lower Chalk, which are quarried for lime-burning. The Totternhoe stone holds much water, which is thrown out by the Chalk marl below in copious springs, which are utilized here and there for water-cress beds. The Melbourn rock of Melbourn is a band of hard and nodular Chalk which has been traced through many counties at the base of the Middle Chalk. This division, and portions of the Upper Chalk with the Chalk rock at its base, occur near Royston and Heydon.

The Gault forms a low-lying tract to the north-west of the Chalk, at Soham and in the vicinity of Cambridge. The Lower Greensand beyond rises into hilly tracts, as at Caxton, Haddenham and Ely. Coprolites have been worked in it at Wicken.

The Kimeridge clay occupies part of the low land near Willingham, and has been exposed in the famous Roswell or Roslyn Hole at Ely, where it is overlain by boulder-clay with a transported mass of Chalk. Corallian limestones with fossils occur at Upware, and the formation is partly represented by the Ampthill clay at Gamlingay, and by rock-beds at Elsworth and elsewhere.

The Oxford clay occurs in the western part of the county near Long Stanton. Boulder-clay and drift gravels are scattered over much of the ground; and Pleistocene gravels with mammoth, rhinoceros, &c., occur at Barnwell. The northern part of the county is mainly Fenland, a portion of the Bedford Level, with peat at Chatteris, and marine gravels at March. Wicken Fen has been preserved as a natural tract of Fenland.

Cheshire. Map 5. Area 657,068 acres.

By far the larger part of this county is a plain formed of New Red rocks and covered with much boulder-clay and shelly drift gravel.

In the western part of the county, as in the Wirral promontory, the Bunter sandstone and pebble-beds are overlain here and there by the Keuper sandstones. The latter are quarried for building-stone, and noted for footprints of Labyrinthodonts at Storeton, about three miles south of Birkenhead.

Keuper sandstones resting on the Bunter constitute the chief water-bearing strata. Together they form the Peckforton Hills with Beeston Castle Hill, and also the scarps of Alderley Edge, where galena, copper-ore and cobalt-ore have been found.

The eastern part of the county is formed chiefly of the red Keuper marls with rock-salt and brine springs at Northwich, Winford, Middlewich, Sandbach, Church Lawton and Nantwich. The salt has been mined, but most of it is obtained by the pumping of brine. At Northwich especially the mining and pumping have led to disastrous subsidences of the land; and some of the meres in the county are probably due to this cause. Rhætic beds and Lower Lias, much concealed by drift, occur near Audlem.

Coal-measures appear in the east, at Macclesfield and Stockport, in a productive coal-field which forms a prolongation of that of South Lancashire. Traces of Coal-measures also occur along the borders of the Dee Valley near Great Neston. East of Macclesfield, and at Congleton Lower Carboniferous rocks form high moorlands with patches of shelly drift at heights up to 1250 feet. There are lime-works at Astbury, in the Carboniferous limestone on the borders of Congleton Edge.

Carrington moss in the valley of the Mersey has been found useful and profitable as a receptacle for the solid organic refuse of Manchester. There are tracts of blown sand at New Brighton, Hoylake and West Kirby. The coast at Leasowe Castle has suffered much from marine erosion.

Sea-side resorts: Hoylake with West Kirkby (sands), New Brighton (sands).

Cornwall. Map 6. Area 868,208 acres.

Cornwall consists mainly of a great mass of clay slates or killas with numerous bands of "greenstone," the whole greatly disturbed and contorted, and penetrated by enormous masses of granite which have altered the bordering rocks. The bolder features in the county are due to these granite tracts. One partially submerged mass has formed the Scilly Isles, about fifty in number, St. Mary's being the chief; another mass occupies the Lands End, with its Logan Rock; a tiny tract rises up in St. Michael's Mount, and other tracts rise eastward at Breage, Carnbrea and St. Day near Redruth, Penryn, Hensburrow, and at Bodmin Moor with Brown Willy (1364 feet) and the tor or weathered pile of rocks known as the Cheesewring.

The chief metalliferous regions at Camborne and Redruth, St. Ives and St. Just, lie on the margin of the granite: there lodes or veins of tin and copper ores occur with some lead and iron-ores. These veins mostly have an E.N.E. direction, while the "cross-courses," filled with quartz, &c., run N. and S. The lodes and cross courses are mostly planes of faulting. Dykes of Elvan (quartz porphyry, &c.) traverse both granite and killas, and extend for considerable distances.

The killas includes representatives of the Lower, Middle and Upper Devonian. The lower beds, with fish-remains, occur at Watergate Bay, Looe and Polperro, and the higher beds along a belt of country from South Petherwin near Launceston to the coast near Minster. Along some horizons there are thin fossiliferous limestones. Slates have been quarried at De la Bole, west of Camelford, and near Tintagel. Older beds of Ordovician age occur at Veryan Bay and at Mullion Island, where radiolarian chert is found (see p. 13).

Newer beds of Culm-measures appear on the coast at Bude and Boscastle, and inland. They contain chert with radiolaria and beds of culm.

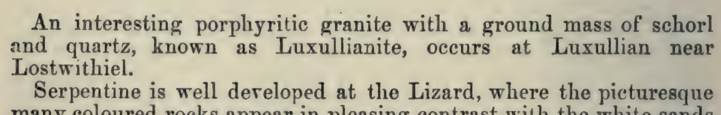


FIG. 8.—SECTION NEAR REDRUTH SHOWING METALLIFEROUS VEINS.

An interesting porphyritic granite with a ground mass of schorl and quartz, known as Luxullianite, occurs at Luxullian near Lostwithiel.

Serpentine is well developed at the Lizard, where the picturesque many coloured rocks appear in pleasing contrast with the white sands of the bays. This rock is manufactured into ornaments, and so are certain serpentinous rocks known as the Duporth and Pollaphant stones. Phonolite occurs at the Wolf rock, south of the Lands End, and gneiss forms the foundation for the Eddystone Lighthouse.

The decomposed granite, as at St. Austell, yields great masses of Kaolin or china clay, and the washings from the works cause the streams to be a milky white. The granite has been decomposed *in situ*: and perhaps by the agency of hydrofluoric acid through fissures, the felspar has been decomposed into clay. Veins of tin-stone with schorl occur in the china clay at Carclaze, St. Austell, and the ore was worked in the time of Edward IV.

At St. Erth fossiliferous Pliocene strata occupy a small area, and deposits probably of the same age occur at St. Agnes' Beacon.

Raised beaches and ancient talus known as "Head," fringe the coasts in places, and there are also extensive tracts of blown sand at Lelant, Phillack and Gwythian, near Hayle, and at St. Piran (or Perran in Sabulo) where the church, smothered for seven centuries, was uncovered in 1835. Evidences of Palæolithic man have lately been noticed at Prah Sands, east of Penzance, by Mr. and Mrs. C. Reid.

Much tin-ore has been obtained from old river-gravels, in the stream-tin works. Native gold was obtained from those of Carnon.

Sea-side resorts: Boscastle (cliffs), Bude (sands and cliffs), Carbis Bay (sands and cliffs), Falmouth (sand and shingle, cliffs), Fowey (estuary); Lizard, Coverack Cove, Kynance Cove, Mullion (cliffs and sandy bays); Looe (cliffs), Marazion (sands), Newquay (sands, cliffs), Penzance (sands and rocks), Porth Towan (sandy bay, cliffs), Port Isaac, Porthpean, Portreath (cliffs), St. Ives (sand, cliffs), Tintagel (cliffs), Watergate Bay (sands, cliffs).

Cumberland. Maps 7 and 8. Area 970,161 acres.

The principal mountain-group in England occupies the central part of this county, and is formed of two main divisions of rocks. The Skiddaw slates extend over much ground on the borders of Bassenthwaite and Crummock Water and around Keswick, and being fairly uniform in character, the hills and mountains, Skiddaw (3058 ft.) and Saddleback (2847 ft.), are smoother in outline than those of the newer Borrowdale series, which is made up of "green slates and porphyries" of volcanic origin. These igneous rocks form the rough crags of Borrowdale, of Scafell (3210 ft.) and Wastwater, Honister Crag, and Hellvelyn (3118 ft.). The Falls of Lodore and other waterfalls are in this region. Masses of syenite occur at Ennerdale, and granite at Eskdale, at Wastdale along the borders of Wastwater, and in Skiddaw Forest.

The Skiddaw slates are not very fossiliferous, but they have yielded some graptolites, and the rocks have been utilized at Keswick in the manufacture of slate pencils. Graphite or plumbago occurs in Borrowdale, and this has been employed in making lead-pencils. Many minerals have been obtained at Caldbeck and Carrockfells north of Skiddaw Forest.

The Carboniferous limestone series, with basement-conglomerate, occurs on the borders of Ulleswater, and forms a belt along the northern margin of Skiddaw Forest at Hesket Newmarket, and westwards to Cleator, where much iron-ore is found. On the eastern side of the Vale of Eden the Lower Carboniferous rocks again appear alongside the Pennine fault, forming Crossfell (2892 ft.), Alston Moor, famed for its lead mines, and other fells northwards by Gilsland Spa to the Northumberland and Scottish borders. The western portion of the county includes the coal-field of Whitehaven, which extends beneath the sea off Workington, and has there been worked. The Vale of Eden is formed of Permian red sandstones and various divisions of the Trias well seen in the cliffs at Wetheral; and these red beds form the foundation of the coast at Silloth and Allonby, at St. Bees Head, and thence to the Duddon estuary, a region much obscured by drift deposits and blown sand. An outlier of Lower Lias, almost wholly concealed by drift, occurs west of Carlisle.

The "green slates"—green, ashy volcanic beds, having a rude cleavage—have been found suitable for roofing, as well as for ordinary building purposes.

Sea-side resorts: Allonby (sands), St. Bees (sands, cliffs), Seascale (sands), Silloth (sands).

Derbyshire. Map 9. Area 658,876 acres.

This county comprises in the north-west a tract of Lower Carboniferous rocks with Millstone grit, in which are included the picturesque Dale and Peak Districts. Dove Dale lies on the western borders near Ashbourne; other dales, such as Miller's Dale, with fine crags of Carboniferous limestone, lie along the Derwent Valley below Buxton. Buxton is a health resort situated over 1000 ft. above sea level, and it is noted for waters that have a temperature of 82°. At Matlock there are mineral waters with a temperature of 68°, and also "petrifying" springs. Numerous caverns occur, as near Matlock and Castleton, and there are fissures and caves with bones of Pleistocene and other remains. Especially noteworthy is a fissure containing remains of the Pliocene *Mastodon*, lately described by Prof. Boyd Dawkins. Ores of lead and various other minerals occur, notably the Fluor Spar or "Blue John" of Castleton. The Carboniferous limestone also contains bands of volcanic rock (mostly dolerite) locally known as "Toadstone."

FIG. 9.—BLUE JOHN MINE, NEAR CASTLETON.

The Peak District is formed partly of Yoredale grits and shales, which appear in the "Shivering Mountain" of Mam Tor (1700 ft.), while Kinderscout (2088 ft.) is formed of a platform of Millstone grit.

The Derbyshire coal-field, the southern part of the great Yorkshire coal-field, extends on the eastern side of the county from Chesterfield to Clay Cross and Ilkeston. On the north-eastern borders there are coverings of Magnesian limestone, quarried, as at Bolsover, for building-stone. The southern part of the county is formed of red rocks, partly of Bunter and Keuper sandstones, the latter yielding building-stone, with more extensive tracts of Keuper marl, yielding gypsum at Chellaston. Part of the Leicestershire coal-field extends into this region. Drift deposits are scattered over the country, and more especially in the lower grounds.

Devonshire. Map 10. Area 1,667,097 acres.

Devonshire gives name to the Devonian system, which comprises grits and sandstones, slates, and limestones. These rocks enter into that part of Devon which lies north of Barnstaple and South Molton —a region of bold swelling moorland hills and fine and often inaccessible cliffs. The hard slates and grits of Lynton and the Valley of Rocks, the contorted slates of Combe Martin and Ilfracombe, with thin bands of fossiliferous limestone, the Pickwell Down sandstones, and the slaty beds of Baggy Point and Pilton, all belong to this great Devonian system. The fine headland of Morte is formed of slates that are probably Silurian.

On the south the Devonian rocks are characterized by more important masses of limestone, at Chudleigh, Newton Abbot, Torquay, and Plymouth—beds largely made up of fossil corals and other organic remains (see Plate 37). The stone is polished for marble at Ipplepen and Babbacombe, near Torquay. Iron, lead, and copper ores occur in places.

At Bolt Head and Salcombe, on the borders of a picturesque estuary, we find highly altered rocks, micaceous and chloritic schists, which may be metamorphic Devonian, if not of much higher antiquity.

The central part of Devon, from Exeter to Bampton, Oakhampton, Bideford, Clovelly, and Hartland, is formed of a trough of Culm-measure shales and grits, a somewhat barren group of Carboniferous rocks which form steep hills and an undulating, well-wooded country. The rocks themselves are much contorted. Near Bideford they contain beds of culm, and at Coddon Hill and other localities there are beds of radiolarian chert. At this horizon along the base of the formation there are beds of limestone and some manganese ore. The limestones appear near Bampton, and are more prominent near Burlescombe, where they are remarkably contorted. Brent Tor is formed of volcanic materials erupted in Carboniferous times.

Perhaps the main feature in Devonshire is the elevated granite area of Dartmoor Forest, characterized by the weathered rocks of Hey Tor, Hound Tor, and Helmen Tor. Lundy Island is almost wholly formed of granite with slates only at the south-eastern end.

To the travellers by rail the red rocks which appear along the coast from Dawlish to Teignmouth form a striking feature. Near St Mary Church there are clayey beds which have been utilized in the Watcombe terra-cotta works. Along the coast Watcombe and other combes are excavated in bold masses of red conglomerate, which extend to Teignmouth, the pebbles formed mainly of Devonian limestone. Near Exeter and Crediton there are volcanic rocks. Eastwards of Exmouth higher beds of red sandstone and marl occur. At Budleigh Salterton there is a famous pebble-bed formed of hard quartzites with Ordovician fossils, the bed itself probably of Bunter age. Further east, at Sidmouth, we find red sandstones and marls of Keuper age, which appear along the base of the cliffs, and at Axmouth are covered by Rhætic Beds, while at Uplyme and Axminster there are quarries in Lower Lias. In this eastern part of Devon the hill tops are capped by Upper Greensand, and also by Chalk at Beer and Seaton. The Greensand extends northwards to form the fine range of Blackdown Hills, flat topped with steep valleys, where the beds in old times have been extensively worked for scythe-stones. They have yielded here, and also on the Haldon Hills south of Exeter, numerous fossils, entirely replaced by chalcedony. The Lower Chalk at Beer has been extensively mined as a freestone.

Beds of Eocene, probably Bagshot age, occur in the Teign Valley above Newton Abbot. These are the Bovey beds of Bovey Tracey, famed not only for lignites, but for the valuable pipe and potters' clay which is shipped at Teignmouth (see p. 129).

The Devonian limestones of South Devon contain several celebrated caves and fissures, those of Kent's Hole, near Torquay, and Brixham have yielded many Pleistocene mammalia and implements of man. Ossiferous fissures have been met with also at Oreston, near Plymouth.

Raised beaches occur at Hope's Nose and the Thatcher Stone, near Torquay. A fine pebble ridge occurs at Northam, near Bideford, and blown sands at Northam Burrows.

At Bindon and Dowlands Cliffs, near Axmouth, a famous landslip occurred in 1839, after an exceedingly wet season, masses of Chalk

FIG. 10.—THE LANDSLIP OF DOWLANDS AND BINDON, BETWEEN AXMOUTH AND LYME REGIS.

h. Chalk,
i. Chert-beds, } Upper Greensand.
k. Sand, }

and Greensand breaking away from the cliff and foundering over the inclined and slippery base of Lias, Rhætic beds, and Keuper marls (see Fig. 10).

Sea-side resorts: Babbacombe (pebble-beach and cliffs), Beer (pebble-beach and cliffs), Bideford (sands), Budleigh Salterton (pebble-beach, cliffs), Clovelly (cliffs, 400 ft.), Dawlish (sands, red sandstone cliffs), Exmouth (sands, red sandstone cliffs), Ilfracombe (rocky, cliffs), Lynmouth and Lynton (cliffs), Morte (cliffs), Paignton (sands), Salcombe (rocky estuary), Seaton (shingle, cliffs), Sidmouth (shingle, sand, cliffs), Slapton (sands), Teignmouth (sands, cliffs), Torquay (sands, cliffs), Woolacombe Bay (sands).

Dorset. Map 11. Area 632,272 acres.

This is a pleasantly diversified agricultural county, and one of considerable geological interest. The more prominent features are formed by the Chalk hills, which extend from Melbury Down on the borders of Cranborne Chase to Blandford, Maiden Newton and Dorchester. Chalk likewise extends across the so-called Isle of Purbeck from Lulworth by Corfe Castle to Ballard Down, north of

Swanage; here it forms a somewhat narrow ridge, as the strata, like those which traverse the Isle of Wight, are highly tilted, and they are also displaced by remarkable overthrust faults. An ancient figure of a giant with club has been formed by removing the turf from the Chalk near Cerne Abbas, and a figure of George III. on horseback has been cut on the slope of the downs north-east of Weymouth.

Resting on the Chalk in the eastern part of the county are the Eocene gravels, sands and clays which form a westerly extension of the Hampshire Basin. Near Verwood on the borders of the New Forest the Reading beds and London clay may be seen, and at Affpuddle Heath and Puddletown there are large swallet-holes in the Chalk on the margin of the Eocene strata. A great part of the Tertiary area consists of Bagshot sands and clays, with coverings of gravel, which form the extensive heaths and commons about Wareham and Wimborne. Near Studland, the Agglestone rock, is an indurated mass of Bagshot beds. A notable feature is Creech Barrow, a hill of Bagshot sands, protected, as Mr. W. H. Hudleston has shown, by a thin capping of probably Oligocene limestone. Blackdown near Portisham is formed of Eocene gravels, and in this neighbourhood there are many greywethers.

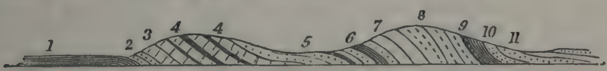


FIG. 11.—SECTION ACROSS THE ISLE OF PURBECK (*Ramsay*).

11, Bagshot beds; 10, London clay; 9, Reading beds; 8, Upper Chalk: 7, Middle and Lower Chalk; 6, Upper Greensand, Gault, and Lower Greensand; 5, Wealden; 4, Purbeck beds; 3, Portland stone; 2, Portland sand; 1, Kimeridge clay.

Beneath the Chalk there is a belt of Upper Greensand, which forms prominent hills in the western part of the county from Shaftesbury, which stands boldly on the crest of the escarpment formed by these strata, to Beaminster and Shipton Beacon east of Bridport. Westwards the Upper Greensand forms the outlying gorse-covered or wooded hills of Pillesdon and Lewesdon Pens, the high grounds above Lyme Regis, and the yellow top of Golden Cap. The basement bed of the Chalk, known as the Chloritic marl, is very fossiliferous in places, as at White Nore, east of Ringstead Bay, between Weymouth and Lulworth. The Upper Greensand is also fossiliferous, and Gault clay has been observed above the Lower Lias clays at Black Ven near Lyme Regis. Lower Greensand occurs also at Punfield, north of Swanage and westwards in the Isle of Purbeck. Wealden beds, consisting of coloured clays, sands and grits, are well seen in Swanage Bay. They directly overlie the Purbeck beds, a group of shelly limestones and clays, well seen in Durlston Bay, at Lulworth and other coves, including the well-known Stair Cove with its contorted bands. The famous Purbeck marble with *Paludina* occurs in the upper beds at Peverel Point, Swanage, the building-stones of Swanage in the middle beds, and marls with gypsum in the lower beds. Purbeck strata occur also at Upway and Portisham. Many fossils may be found (see p. 26 and Plate 43).

The Portland beds form the bold cliffs of Durlston and St. Alban's Heads, and the mass of the Island of Portland. The celebrated freestone occurs in the uppermost portion, below which are limestones with many bands and nodules of chert and soft sandy beds. They rest on the Kimeridge clay, made up of dark shales with cementstones, which are well seen in the cliffs and on the foreshore at Kimeridge and Ringstead Bay, and at the base of the northern cliffs of Portland. Beds of bituminous shale, including the "Kimeridge coal," occur at Kimeridge, and they have been worked for the production of naphtha, &c. Discs of shale known as Kimeridge coal-money have been found in this neighbourhood; they are considered as waste materials from ornaments or utensils that had been shaped from the shale. Many fossils occur in the shales and in hard bands at the base of the formation. Below come the Corallian strata so well developed at Weymouth, by Sandsfoot Castle and again near Osmington. Richly fossiliferous layers occur in the cliffs and in reefs on the foreshore—beds with *Trigonia* being especially noteworthy. Iron-ore occurs in the upper beds at Abbotsbury, where red fields and red banks in the lanes are very conspicuous. Freestones have been worked in this series at Marnhull and Todbere near Sturminster Newton. Beds of oolite and pisolite also occur. The Oxford clay below is well seen in cliffs and cuttings north of Weymouth, and it occurs in the Vale of Blackmore. In this formation large *Gryphæa* and other fossils as well as septaria occur. The Cornbrash beneath is very fossiliferous, and may be seen along the borders of the clay region near Stalbridge, Bishops Caundle, &c., and southwards near Radipole. The Forest marble, with a basement fossil-bed full of *Rhynchonella* and other fossils, occurs next in succession, and is well shown on the borders of the Fleet at Langton Herring near the Chesil Bank, at Eype, and inland, as at Long Burton, where the limestones have been quarried. These beds form a bold scarp, which overlooks the clays of the Fuller's earth. This lower formation contains a band of Fuller's earth rock, locally quarried, as at Thornford, near Sherborne. In it many fossils occur. The clays appear in the cliffs west of Bridport Harbour. Again we have a richly fossiliferous formation in the Inferior Oolite, well shown in quarries near Sherborne and Bradford Abbas, near Beaminster, and also near Bridport and Burton Bradstock. Ammonites are very abundant, as well as brachiopods. Underlying the Oolite come the Midford sands, yellow sands with hard bands of calcareous sandstone, which form the main portion of the picturesque yellow cliffs from Bridport eastwards to Burton Bradstock. These beds are also seen inland in many deeply cut sandy lanes or "hollow ways." Dorset, again, is noted for its development of Lias, so well shown in the cliffs below Thorncombe Beacon and Golden Cap, and westwards to Charmouth and Lyme Regis. Remains of the great saurians *Ichthyosaurus*, *Plesiosaurus* and *Dimorphodon*, were first brought to notice from this region—and numerous other fossils, fishes, crustacea, ammonites and belemnites are to be obtained. The higher portions of the Lias consist mainly of marls and clays—the lower beds of limestones worked at Lyme Regis for hydraulic lime and cement. Beneath this

"Blue Lias" are beds of White Lias of Rhætic age which are exposed at Pinhay Bay, west of Lyme Regis.

The Chesil beach, formed largely of chalk flints and greensand chert, contains also many stones from the pebble-bed of Budleigh Salterton. It connects the Isle of Portland with the mainland, and is noted for the gradual diminution in size of its pebbles westwards to Bridport Harbour. Much iron-pyrites occurs in the Lias shales at Black Ven, and this has at times been collected during the winter months for economic purposes. In 1755 the decomposition of the pyrites led to spontaneous combustion of the bituminous shales at Charmouth, and in 1890 there was a similar combustion, pictured in the *Daily Graphic* of February 19th, as the "Eruption of Golden Cap." Sulphurous waters, due to the decomposition of pyrites, occur at Nottington and Radipole.

Sea-side resorts: Bridport Harbour (West Bay), Charmouth and Lulworth (shingle beach, cliffs), Lyme Regis (stony beach, sands, and cliffs), Swanage (sandy and stony beach, cliffs), Weymouth (sands, pebble beach, cliffs).

Durham. Map 12. Area 647,281 acres.

Durham is largely a mining county. The greater part of the land is formed of Carboniferous rocks. The lower strata of Carboniferous limestone and Millstone grit belong to the Pennine Chain, and form the moorlands of the west, at Staindrop and Barnard Castle, and over the forests and valleys of Tees Dale and Wear Dale, with their lead and iron-mines. Silurian rocks occur over a limited area above Middleton-in-Teesdale, where there was a slate-pencil mill; and here occur sills and dykes of basalt, one of which extends in an east-north-easterly direction to Quarrington. In the central part of the county the productive Coal-measures occur, and they no doubt extend beneath the Permian and other New Red rocks in the eastern part. The Coal-measures form the southern part of the Newcastle coal-field extending from Gateshead and Jarrow to Lambton, Hetton-le-Hole, Durham, and Bishop Auckland, and beneath the Permian rocks at Monk Wearmouth and other places. The Magnesian limestone covers a large part of East Durham, and is exposed in the fine cliffs of Marsden and southwards to Hartlepool. It exhibits many curious concretionary structures, which simulate coralline and other organic forms. Much of the rock is dolomitic, and is used in the manufacture of sulphate of magnesia. Elsewhere there are large limeworks. Remains of fossil fishes have been found in the lower beds of marl slate at Ferry Hill and other places. Red marls and sandstones, with gypsum and important beds of rock-salt, have been proved at Seaton Carew and elsewhere between Port Clarence and Hartlepool. In this district, and indeed all over the county, there is much glacial drift.

Sea-side resorts: Marsden (rocks, cliffs), Roker (sandy, cliffs), Ryhope (shingly, cliffs), Seaton Carew (sands), South Shields (sands).

Essex. Map 13. Area 987,028 acres.

This agricultural county occupies a part of the London Basin, with the Chalk on the north rising into the Downs south-east of Royston, near Barley, Chishall, and at Saffron Walden. The Chalk appears again through disturbance at Purfleet and Grays, where it is extensively worked for lime, cement and whiting. Some of the largest pits in the country are to be found here. Southwards of Bishops Stortford and Great Yeldham the foundation of the county is mainly London clay with underlying Reading and Thanet beds, but their outcrop is largely concealed by boulder-clay and glacial sands and gravels which are distributed over the greater part of the county. Between Epping and Dunmow especially there is a great tract of boulder-clay, and latterly it has been traced as far south as Hornchurch beneath the Thames Valley gravel. Connected with the boulder-clay is a deeply eroded trough in the Cam Valley, near Great Chesterford, while on the summit of the scarp near Barley the Chalk has been greatly disturbed by glacial agency. Apart from the Drifts there are outliers of Bagshot sands and pebble gravels at Highbeech, Brentwood, Langdon Hill, and Rayleigh. These are picturesque tracts, and the view from Langdon Hill is most extensive. Patches of fossiliferous Red Crag occur at Walton-on-the-Naze and inland at Oakley and Beaumont.

The Thames Valley deposits of gravel and brickearth have yielded mammoth, rhinoceros, and other remains at Ilford and Grays; while similar deposits of like age have been met with at Clacton-on-Sea and Copford, near Colchester. More recent deposits, with remains of beaver, &c., have been met with at Walthamstow, and thick alluvium occurs at Tilbury (see p. 34).

Septaria occur in the London clay, and were formerly dredged off Harwich for the manufacture of Roman cement.

Sea-side resorts: Brightlingsea (estuary of Colne), Clacton-on-Sea (sandy and shingly beach, low cliffs), Dovercourt (sand), Frinton-on-Sea (sandy), Southend (sandy and muddy, low cliffs), Walton-on-the-Naze (sandy, cliffs).

Gloucestershire. Map 14. Area 795,734 acres.

This county contains a longer list of geological formations than any other. The gneiss at the south end of Malvern, and certain old grits at Huntley, are pre-Cambrian. Silurian rocks with bands of limestone occur at May Hill and with also volcanic bands near Tortworth; and these are bordered by the Old Red sandstone.

The picturesque and wooded tracts of the Forest of Dean are formed of Carboniferous limestone and Millstone grit, which occupy a basin supporting the Dean Forest coal-field. Fine cliffs of limestone border the Wye, and in some parts the rocks are repositories of iron-ore, which fills great cavities.

The Bristol coal-field extends northwards from Bristol towards Wickwar, and it is bounded by the Millstone grit and Carboniferous limestone, which, however, are much concealed in places by overlying New Red rocks and Lias. The older rocks are seen in the Avon Gorge. Coal-measures were penetrated in the Severn tunnel. These older rocks were bent, disturbed, and eroded prior to the succeeding New Red rocks, which stretch irregularly over them. Sulphate of strontium is worked at Wickwar in the Keuper marl. The Rhætic beds, with bone-bed and other fossiliferous layers, are well seen at Aust Cliff and Garden Cliff near Westbury-on-Severn. Near

Bristol the Cotham or Landscape marble occurs in the upper part of this division. Above comes the Lias, which forms a belt of lower ground beneath the bold escarpment of the Cotteswold Hills. The Vale of Gloucester is formed partly of Lias and partly of the Red marls, with coverings of gravel. Rich fossil localities occur in the Lower Lias near Gloucester and Cheltenham, and in the outliers of Middle and Upper Lias at Dumbleton and Churchdown Hills.

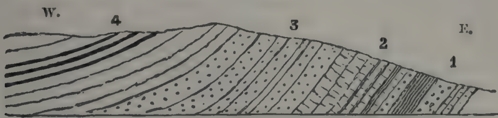


FIG. 12.—SECTION IN THE FOREST OF DEAN (*Ramsay*).
4, Coal-measures ; 3, Millstone grit ; 2, Carboniferous limestone series ; 1, Old Red sandstone.

The Cotteswold Hills form a fine range, with a prominent crest here and there marked by ancient camps and beacons. Wotton-under-Edge, Stinchcombe and Dursley, Stroud, Painswick, Leckhampton, Birdlip, Crickley, and Cleeve Cloud are all famous localities for fossils, freestones and other varieties of rock. The strata are inclined to the south-east, and are overlaid by Fuller's earth clays and Great Oolite. Minchinhampton is the most noted locality for fossils of the Great Oolite, but other quarries near Cirencester are rich in organic remains, corals, brachiopods, &c. The Forest marble and Bradford clay are well developed near Cirencester, and the former extends through Tetbury and Badminton. The beds are worked for slates at Poulton and other places. The Cornbrash, again, is well exposed near Cirencester and Fairford, fossiliferous as usual. This is overlain by the Kellaways beds, which were well exposed in the railway cutting at South Cerney, where they contain large doggers of calcareous sandstone. In the same tract, and bordering the Thames to Lechlade, the Oxford clay occurs.

Much rubble of oolite borders the Cotteswolds at Leckhampton, Syreford, Bredon Hill and other places, and this may be due to subaërial waste during the glacial period. Traces of boulder-clay occur in the vale of Moreton, south of Chipping Campden. At Chalford and Dursley there are "petrifying" springs, and at Dursley the tufa has been used for building purposes. At Clifton there are hot-wells (70° to 76°), at Cheltenham saline and chalybeate waters, and at Gloucester saline waters.

Hampshire. Map 15. Area 1,037,764 acres.

This county is formed entirely of Cretaceous, Tertiary and newer strata. In the northern part there is a tract of Reading beds, London clay and Bagshot beds, which occupy a portion of the London basin. These strata extend from Farnborough to the old Roman town of Silchester and westwards to Kingsclere. Here the Chalk is highly tilted and bent into an anticline, the eroded summit of which leaves bare the Upper Greensand of Burghclere. Southwards there is an undulating expanse of Chalk, from Basingstoke to Andover and Winchester.

Eastwards from near Alton to Petersfield on the borders of Surrey, Upper Greensand, Gault, and Lower Greensand appear, in a picturesque region which includes Selborne, the home of Gilbert White, Woolmer Forest on the Gault, and the Lower Greensand hills of Bramshot.

South of Winchester we again enter a Tertiary area, the Hampshire Basin, which includes the Reading beds and London clay along the Chalk borders. These are bent into a gentle anticline near Havant and Fareham, which has been much planed down and concealed by Pleistocene gravel and brickearth. Remnants of an old sea-beach occur below Portsdown Hill. The New Forest is situated on a tract of Bagshot and Bracklesham beds, and partly on Oligocene clays and sands. On the coast at Barton the Barton clays are richly fossiliferous, and many fossils have also been obtained at Hordle (or Hordwell). Westwards the Bagshot beds of Bournemouth have yielded many plant remains, including fig, cinnamon, palm and aralia.

The northern part of the Isle of Wight is formed of the Oligocene and Eocene strata. Here are many famous localities for fossils (Plates 47 and 48). Along the central part of the island the Chalk and other strata are highly inclined and even vertical in places: notably the many-coloured Bagshot sands of Alum Bay and Whitecliff Bay.

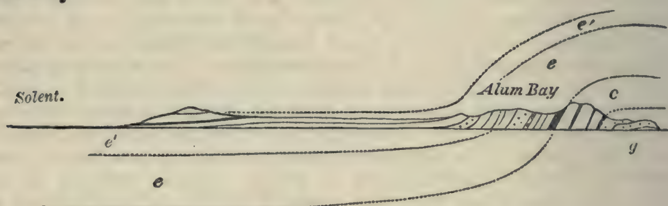


FIG. 13.—SECTION ACROSS THE ISLE OF WIGHT (*Ramsay*).
e′, Oligocene, Bracklesham and Bagshot beds; *e*, London clay and Reading beds; *c*, Chalk, Upper Greensand and Gault; *g*, Lower Greensand and Wealden.

The Chalk, which is so much tilted in its range from the Needles to Culver Cliffs, occurs also in an outlier on the high grounds above Ventnor. The Upper Greensand is well seen beneath it, and the strata have broken away over the slippery foundation of Gault forming the famous and picturesque landslips that border this coast. The Lower Greensand is well seen on either side of Sandown, and in the lovely chines of Shanklin and Blackgang. At Shanklin there is a chalybeate spring. Wealden beds are exposed on the coast near Brixton; they have yielded remains of *Iguanodon* and other saurians.

Sea-side resorts: Alum Bay (sands and cliffs), Bembridge, Brading and Cowes (low cliffs), Freshwater (chalk cliffs), Ryde (low cliffs), Sandown (sands, cliffs), Shanklin (sands, cliffs), Totland Bay (sands, cliffs), Ventnor (stony beach, cliffs); Barton-on-Sea, Boscombe (sands and cliffs), Bournemouth (sands and cliffs), Hayling Island (sands), Southsea (shingly).

Herefordshire. Map 16. Area 537,363 acres.

Herefordshire is largely formed of Old Red sandstone, which extends from the grand scarp of the Black Mountains on the south-west to the borders of the Malvern range, and from Tenbury on the north to Goodrich on the borders of Dean Forest. It comprises a group of red and yellow sandstones, quarried at Cradley and other places, of red marls, calcareous sandstones and limestones known as cornstones, as well as beds of quartz conglomerate.

Older rocks protrude in places. In the Malvern range at the Herefordshire Beacon, the Archæan gneiss appears to be thrust over Silurian rocks which extend westwards to Ledbury, while further south Cambrian shales and quartzites intervene. At Woolhope an inlying mass of Silurian strata, mainly shales with bands of Woolhope, Wenlock and Aymestry limestones, protrudes in a denuded anticline, in old days termed a "valley of elevation."

Silurian rocks also enter the county on the borders of May Hill, and again to the north at Ludlow, Aymestry and Leintwardine, localities famous for fossils and classic in the history of geology (Plate 36).

The Carboniferous limestone appears in fine cliffs along the Wye valley, at Great Doward south of Whitchurch, noted for King Arthur's cave, an old hyæna den, in which bones of cave-lion, rhinoceros, mammoth and reindeer have been found. Valley gravels border the Wye at Hereford and other places.

Hertfordshire. Map 2. Area 406,161 acres.

This county occupies a part of the London Basin and bordering tracts on the north. The oldest formation at the surface is the Gault, which, together with the Chalk marl, forms the low ground north of Baldock and Hitchin. Near Arlesey the Gault has been extensively worked for brickmaking, and the Chalk marl for cement. The Chalk rises to form the Chiltern Hills near Tring, Kensworth (904 feet) and the Royston Downs eastwards of Baldock. The Upper Chalk at Barley and Reed has been locally disturbed by glacial action. Thence to the south-east there is a broad dip-slope of Chalk covered with much clay-with-flints, drift gravel and boulder-clay, and near Rickmansworth, Watford, Hatfield and Hertford by the Reading beds, and London clay. Outliers of these formations occur in the picturesque region of Welwyn. The Reading beds comprise sands, mottled clays, and also pebble-beds made up of flint-pebbles, that are sometimes cemented into a hard rock known as the Hertfordshire pudding-stone.

The clay-with-flints rests on a very irregular "piped" surface of Chalk, as may be seen near St. Albans and Harpenden.

Patches of pebbly drift gravel occur on the London clay at Barnet, Totteridge, and other places; and tracts of valley gravel border the Lea, and its tributaries from Harpenden, to Hertford and Ware, and southwards.

In deep borings Silurian rocks were proved at a depth of 795 feet below the Gault at Ware; and Devonian rocks were proved at a depth of 980 feet beneath Gault at Turnford by Cheshunt.

Huntingdonshire. Map 4. Area 234,218 acres.

This is for the most part a low-lying county of clay and fenland formed largely of the Oxford clay. This is well exposed in the large brickyards at Fletton by Peterborough, and there are pits near Ramsey, St. Ives, and St. Neots, where bands of limestone occur in the clay. At St. Ives there is a band of Corallian rock. Much of the ground is covered with boulder-clay, and there is no more tenacious soil than that which, as in the vicinity of Warboys, is derived from Oxford clay and boulder-clay. Transported masses of Chalk of considerable extent have been observed in the boulder-clay at Catworth, north of Kimbolton.

In the southern part of the county the Lower Greensand appears at Waresley, south-east of St. Neots.

At Yaxley there is an inlier of Cornbrash, and the same formation, with Great Oolite clays and limestones, appears on the borders of the Nen Valley near Overton Longville, and also at Alwalton, where the shelly limestones have been polished as marble.

Stilton, near Yaxley, gave name to the famous Stilton cheese, not because it was made in the district, but because it was formerly sold at that locality to passengers travelling by coach on the great north road. Much of it is made in Leicestershire.

Bordering the Ouse and the Nene there are belts of valley gravel, and fertile alluvial meadows; and in the fenland there are tracts of peaty ground with occasional meres.

Kent. Map 17. Area 995,344 acres.

The strata in this county are but little obscured by superficial drifts, which so greatly mask the eastern and many of the midland and northern counties. The northern part of the county is occupied by Eocene strata, the lowest division of which, the Thanet beds, takes its name from the so-called Isle of Thanet. The sands of which this formation is composed occur near Minster and on the borders of Pegwell Bay. They are well seen in the cliffs between Reculvers and Herne Bay, where many fossils have been obtained, and also in pits at Erith and elsewhere.

The Woolwich and Reading beds have been exposed in pits at Charlton near Woolwich, near Chiselhurst, and at Upnor near Rochester, where the fluvio-marine type of Woolwich beds occurs. Above these strata there is a band of sands and pebble-beds, known as the Oldhaven and Blackheath beds, the pebble-beds occurring about Blackheath and Bromley, and sands near Oldhaven Gap, east of Herne Bay.

The London clay occupies much ground in the south-eastern part of the London area, as at Sydenham and Forest Hill. It is well seen in the cliffs of Sheppey, where many landslips have occurred and where many fossils have been obtained, notably plant-remains, mollusca, crabs, sharks, turtles, and birds.

The Chalk is brought to the surface along the borders of the Thames near Greenwich, and was exposed in several old pits at Loam Pit Hill near Lewisham, and at Charlton. It is seen also at Erith and in many pits at Northfleet and Gravesend, localities famous for Upper Chalk fossils. Here and also along the Medway Valley, as at Halling, above Rochester, there are many lime and cement works. The Chalk is well exposed in the cliffs of Thanet from Birchington by Margate to Broadstairs and Ramsgate, and again from the south of Deal by Dover to the Warren, near Folkestone.

At the depth of 1204 feet below the surface Coal-measures have been proved at Dover, beneath Jurassic and Cretaceous rocks. Oxford clay has been reached beneath Lower Greensand and higher strata at Chatham, at a depth of 943 feet.

The Chalk gradually rises from the north towards the south, where in a long stretch of country it forms the North Downs from Knockholt and Chevening eastwards to the sea-coast north of Folkestone: an escarpment which is trenched by the rivers Stour, Medway, and Darent. Remnants of Crag, preserved in "pipes" of the Chalk occur at Lenham, near Charing, and other places. Below the Chalk there is a thin outcrop of Upper Greensand, which may be traced from Westerham to Otford; it overlies the Gault clay and is replaced by that formation at Burham and further east. The Gault forms a low-lying tract of pasture land, and it is worked in places for brickmaking. Many fossils are to be obtained, and Folkestone in particular is a noted locality.

From the Gault vale the Lower Greensand gradually rises towards the south and forms a fine escarpment overlooking the vale of Weald clay, south of Sevenoaks, and thence by Ashford to the coast at Hythe and Sandgate. The highest portion, or Folkestone beds, is composed of sands, often pure siliceous sands that have been used near Aylesford and Berstead for glass-making. A lower division, known as the Sandgate beds, contains clayey bands, then come the Hythe beds, made up of soft, sandy layers or "hassock" and hard siliceous limestones known as Kentish Rag. These beds are well seen in quarries near Maidstone, where the Rag is used for building-stone and road-metal. Here many fossils occur, notably *Iguanodon*. The rock is much jointed and fissured, and in fissures at Maidstone and Ightham many Pleistocene mammalia have been obtained.

A thin band of Atherfield clay is found at the base of the Lower Greensand, and below is the Weald clay, which forms a low-lying but undulating wooded tract. On both Lower Greensand and Weald clay are many hop grounds. Beneath the Weald clay, but rising to form hilly ground, is a group of sands and clays known as the Hastings beds, which extend from Tonbridge to Tunbridge Wells and thence to Cranbrook and Tenterden. They form a pleasant residential area. Hardened masses of sandstone stand out in places, as near Tunbridge Wells, the Toad Rock being a well-known example. At Tunbridge Wells chalybeate waters are met with; and iron-ore occurs in the Wadhurst clay, one of the divisions of the Hastings beds.

Romney Marsh is an old alluvial tract, while at Dungeness there is a great tract of shingle. Valley gravels and brickearths border the Thames and tributaries, near London, at Dartford, and Crayford near Erith; and palæolithic implements and remains of mammoth, rhinoceros, &c., have been found. The neighbourhood of Ightham is noted for the earlier Eolithic implements made known through the researches of Sir Joseph Prestwich and Mr. Benjamin Harrison.

At Shellness in Sheppey and at Shellness by the River Stour, north of Sandwich, considerable accumulations of recent marine shells occur, and these have been worked for making paths, &c.

Sea-side resorts: Birchington-on-Sea (shingle and sands, chalk cliffs), Broadstairs (sands, chalk cliffs), Deal (shingle). Dover (shingle, chalk cliffs), Folkestone (sands, shingle, cliffs), Herne Bay (sands, cliffs), Hythe (shingle), Margate (broad sands, chalk cliffs), Ramsgate (sands, chalk cliffs), St. Margarets (shingle, chalk cliffs), Sandgate (shingle, sand, cliffs) Sheerness-on-Sea (shingle, sand, cliffs), Westgate-on-Sea (sands, chalk cliffs), Whitstable (shingle and sand).

Lancashire. Maps 8 and 18. Area 1,207,605 acres.

This is a region of mountain, moorland and plain. On the northern and detached portion of the county, including Furness and a part of the Lake District, older Palæozoic rocks are developed. On the north-west borders at Seathwaite we find the volcanic series of Borrowdale with Coniston Old Man, bordered by the Coniston limestone (Ordovician).

Silurian rocks extend southwards on the borders of Coniston Water and Windermere to Cartmel and Ulverston. These include the Coniston flags and grits, with the Braythay flags; and they yield many graptolites, trilobites, brachiopods and mollusca.

Carboniferous limestone occurs on the southern tracts of Furness, at Ulverston and Dalton-in-Furness, also at Cartmel and Grange. Rich hæmatite ore occurs in pockets and fissures in the rocks. The limestone, with its characteristic "scars" or crags, is well seen near Carnforth, at Clitheroe, Whalley, and other places. High moorlands of Millstone grit occur east of Lancaster, at Pendle Hill east of Clitheroe, and between Blackburn, Bolton and Rochdale, as at Haslingden, famous for flagstones.

The Lancashire coal-field extends from Burnley and Blackburn on the north to Wigan, St. Helens and the neighbourhood of Manchester on the south. Wigan is noted for its cannel coal. A small part of the Ingleton coal-field is also included in the county.

Permian sandstones and Triassic rocks border the Mersey from Manchester to Liverpool and fringe the eastern coast by Ormskirk, Preston and Garstang—a tract much covered with Glacial drift and newer deposits, such as the Shirdley Hill sand, which is largely wind-drifted. The Bunter sandstone is quarried for building-stone, east of Liverpool.

The boulder clay, is well seen in the cliffs at Blackpool. Elsewhere from Seaforth to Southport, at Lytham and Fleetwood, sand dunes fringe the flat coast-lands. Peaty tracts occur at Chat Moss, and Glazebrook.

Sea-side resorts: Arnside (sand and shingle), Blackpool (sands, cliffs), Fleetwood (sands), Grange-over-Sands (sands, limestone rocks), Lytham (sands), Morecambe or Poulton-le-Sands (broad sands), St. Anne's-on-Sea (sands), Southport (sands).

Leicestershire. Map 19. Area 527,124 acres.

In this county we find one of the most ancient mountain groups in England, that of Charnwood Forest, whose peaks of slaty rock and hornstone, grit and agglomerate, with intrusive masses of granite, syenite and porphyroid, stand out in curious rocky eminences, like kopjes, from a mantle of Keuper marls and Drift. This is a fine bracing tract rising to over nine hundred feet at Bardon Hill, which, like Peldar Tor, is formed of porphyroid. Elsewhere near Woodhouse Eaves, at

Swithland where slates were largely worked, in Bradgate Park, at Markfield, Beacon Hill, at Whittle Hill, where the Charley Forest hone-stones are obtained from hard fine-grained volcanic tuffs, the old Charnian rocks are to be seen; while masses of syenite appear at Markfield and Grooby, and further south at Croft and Enderby; and granite is largely quarried at Mount Sorrel. These intrusive rocks are employed for road-stone and paving setts, while the waste chips are utilized in places for the manufacture of artificial pavement. Attention has lately been called by Prof. W. W. Watts, to the smoothed and furrowed surfaces of the granite at Mount Sorrel, that have been exposed by the removal of Keuper marls. Evidence is here furnished of wind-erosion of the old mountain-ridges in Triassic times, before they were buried by the Keuper marls.

West of Charnwood Forest the Coal-measures come to the surface at Ashby-de-la-Zouch and Moira; and tracts of Carboniferous limestone, with much dolomite, appear at Grace Dieu, and at Breedon, where there are fine quarries. Brine springs occur at Ashby-de-la-Zouch.

The Keuper marls occupy the country about Market Bosworth and Hinckley and eastwards to Leicester, where there are intercalated bands of sandstone, and occasional beds of gpysum. The eastern part of the county is occupied by the Lias with extensive coverings of boulder-clay, and drift gravels.

The Rhætic beds, which intervene between the Keuper and the Lias, have been exposed at Wigston and near Leicester.

The Lower Lias is noted for its Blue Lias lime and cement prepared at Barrow-on-Soar, and utilized in the manufacture of artificial pavement. The limestones at the base of the Lias have yielded many fossils, saurians, fishes and crustacea, as well as mollusca, &c.

The Lias and boulder-clays form a famous hunting country, of which Melton Mowbray is the centre with Market Harborough on the south and the Vale of Belvoir on the north. Westward on the borders of the red marl lie Loughborough and the region of Quorn. The Middle Lias occurs at Billesdon and Tilton, and locally contains iron-ore at Tilton and at Eastwell and Eaton. Northampton sands and Inferior Oolite occur at Waltham-on-the-Wolds. Saline waters have been met with at Shearsby, and saline-chalybeate waters at Neville Holt.

Lincolnshire. Map 20. Area 1,693,547 acres.

In this county the strata outcrop in fairly regular belts from north to south. Coal-measures, Permian and Bunter have been proved in a boring at South Carr, near Haxey, but the oldest formation exposed is the Keuper, which rises from the alluvial flats bordering the western side of the Trent to form the Isle of Axholme at Epworth and Crowle, where gypsum occurs. Eastwards of the river the red marls form the base of the low escarpment of the Lias from Burton-upon-Humber to Gainsborough and further south. Rhætic beds have been observed in the railway-cutting at Lee. The Lias forms for the most part a vale, bordered on the east by the fine escarpment of the Lincolnshire limestone (Inferior Oolite), which is cut through by the

Witham at Lincoln. Along the summit of the escarpment, which is known as The Cliff, the Ermine Street runs, while the vale extends southwards to Grantham. In the Lower Lias there occurs the ironstone so largely worked at Frodingham, while in the Middle Lias there is the iron-ore of Denton and Caythorpe. The Upper Lias, a dark blue clay, is worked for brickmaking at Lincoln. All these divisions are fossiliferous. In the basement portion of the Inferior Oolite at Greetwell iron-ore has again been worked. The limestone above—the Lincolnshire limestone—occupies a broad belt of country: uplands with stone fences, and it yields famous freestone at Ponton and Ancaster, and other building-stone at Lincoln, and also at Kirton Lindsey where the stone is employed in the manufacture of lime and cement. The limestone is an important water-bearing formation, and wells sunk into it at Bourne and elsewhere have yielded abundant supplies. The eastern tract of Lower Oolite is formed of the Great Oolite series with the Cornbrash—all more or less fossiliferous. Then there is a belt of low-land formed of Oxford, Corallian and Kimeridge clays. The lowest portion on the west includes sandy Kellaways beds, and the clays in general are locally worked for bricks. There are many brickyards at Market Rasen in the Kimeridge clay, with iridescent fossils. Woodhall Spa, noted for its iodine, derives its waters from a deep well. Some of the shales in the Kimeridge clay are highly bituminous. These beds on the east are overlain by a group of Lower Cretaceous rocks, the Spilsby sandstone and Tealby beds with the Claxby iron-ore. The Red Chalk represents the Gault at the base of the White Chalk which forms the Lincolnshire Wolds. Here and there bands of reddish Chalk occur higher up in the White Chalk.

Boulder-clay occurs plentifully on the Chalk tracts and elsewhere in the northern part of the county, where there is also much Glacial sand, some of it wind-drifted. Boulder-clay also extends around Ponton, where it contains huge boulders of Oolite. The eastern part of the county is largely fenland formed of silt and peat, as on the borders of the Wash, at Spalding, and Boston. The tidal warp of the Trent and Humber is due to the waste of Holderness Cliffs. Blown sand occurs on the coast.

Sea-side resorts: Cleethorpes, Mablethorpe, Skegness and Sutton-on-Sea (sands).

Middlesex. Map 2. Area 181,301 acres.

The foundation of this county, which occupies a part of the London Basin, is largely London clay, resting on the Reading beds which outcrop at Pinner and Northwood, and again on the Chalk, which is well seen in pits at Haresfield north of Uxbridge.

The London clay forms an undulating grass country around Harrow, Wembley Park, and Edgware. Some of the higher grounds at Harrow, Hampstead and Highgate are capped by Bagshot sands; Stanmore Hill, the highest in Middlesex (500 feet), is formed of pebble gravel, perhaps of Eocene age, while other hills, as at Finchley and Hendon, are covered by boulder-clay, sand and gravel. A small patch of gravel also occurs on Mill Hill. The broad valley of the Thames is occupied by brickearth and gravel, which stretches from

Uxbridge to Southall, Ealing, Paddington and Islington and southwards to the Thames; and similar deposits occur eastwards along the Lea Valley to Tottenham and Enfield. There are many brickyards between West Drayton and Southall, while market gardens and fruit grounds extend to the south at Heston and Hounslow. The older settlements were made on the valley gravels and on the patches of sand and gravel on the hills, as they readily yielded supplies of water in spring or well. The clay tracts from Regent's Park to Camden Town and north-westwards to Kilburn, Harrow and Edgware were but thinly populated until supplied from a distance by water companies or locally from deep wells.

The Thames Valley deposits have yielded palæolithic implements, and remains of mammoth, hippopotamus, rhinoceros, &c.

At Meux's Brewery, Tottenham Court Road, a deep boring has been carried through the Chalk and Gault to Oolite and Devonian rocks, the latter having been reached at a depth of 1066 feet. At Kentish Town red clays and sandstones were encountered at a depth of 1113 feet, and penetrated to the depth of 1302 feet. Their age, whether Triassic or Devonian, is uncertain.

Monmouthshire. Maps 16 and 32. Area 341,688 acres.

In this county we have the eastern portion of the great South Wales coalfield, which is connected with the important docks at Newport. The oldest rocks are the Silurian, which appear near Rumney, and occur over the Usk district, where they are bent into a gentle anticline. They are bordered by the Old Red sandstone, which comprises red marls and concretionary limestones (cornstones), red sandstone and quartz conglomerate. The Sugar Loaf, north-west of Abergavenny, is formed of these rocks, and rises to 1954 feet. Skyrrid Fawr lies to the east. Somewhat steeply inclined are the rocks bordering the coal-field, for there is but a narrow outcrop of Carboniferous limestone and Millstone grit—the latter rock, however, forms a fine escarpment in the Blorenge on the north-east. The Coal-measures occupy the ground from Pontypool to Tredegar, including the Ebbw Vale and Sirhowy Valley, and the borders of the Rhymney Valley, the upland portions of which are highly picturesque regions, especially in the tracts formed of Pennant Grit.

More extensive areas of Carboniferous limestone appear in the eastern part of the county, stretching southwards from the Wye Valley at Tintern and Chepstow. New Red marl and Dolomitic conglomerate occur near Portskewet and westwards towards Newport, and Lower Lias at Liswery, east of Newport, where the "Blue Lias" limestone is burned for lime and cement. Here saurian remains and other fossils have been obtained. Between the red marl and the Lias, the Rhætic beds occur, with black shales and representative of Cotham marble. These beds have been exposed in Gold Cliff, now largely concealed by masonry, where the iron-pyrites in the Rhætic shales gave name to the cliff. There is a bone-bed here in the green marls below the black shales. Extensive mud flats border the Severn alongside of fertile alluvial meadow-lands.

Norfolk. Map 21. Area 1,308,440 acres.

This is essentially an agricultural county. The foundation is mainly the Chalk which is well shown in the cliff at Hunstanton, and occupies the country southwards to Swaffham, Stoke Ferry, and Thetford, and eastwards to Wells and Weybourn, Norwich and Diss. Over this tract it is covered largely by boulder-clay and drift sands and gravels, less so in West Norfolk than in Central Norfolk. Near Aylsham and Norwich the Chalk is exposed only in the river valleys. The general dip being eastwards, we have an ascending series in the Chalk from Hunstanton and Stoke Ferry to Norwich, and various groups of fossils are found in successive divisions. Large tubular flints known as Paramoudras occur in the Upper Chalk. The highest beds are those observed on the coast at Trimingham, where the strata are disturbed by glacial action. Beneath the White Chalk is the remarkable Red Chalk of Hunstanton, a bed about three feet thick, containing many fossils of the age of the Gault. Lower still comes the Lower Greensand, consisting of a brown carstone in Hunstanton Cliff, including beds of sand and clay near Snettisham, and extending southwards to Sandringham, near Lynn, and Downham Market. The Lower Greensand forms a picturesque escarpment overlooking the Wash and fenland, with many tracts of common and heathland. The strata overlie the Kimeridge clay, which is exposed here and there on the fen borders and is dug for brick-making at Downham Market. At West Dereham coprolites have been worked in the Gault clay.

Above the Chalk at Yarmouth there are beds of London clay and Reading beds, not exposed to the surface. Along the Waveney Valley at Aldeby, in the Yare Valley at Norwich, Thorpe, and Bramerton, in the Bure Valley at Horstead and Coltishall, and along the coast at Weybourn, there are beds of Norwich Crag, with many fossil mollusca, and remains of mastodon, &c. These beds on the coast are overlain by the Forest-bed series of Cromer, in which remains of fossil mammals, and other vertebrates, mollusca, plants, &c., are to be found.

The Glacial Drifts form the mass of the Cromer cliffs and extend over the greater part of the county. Fertile loams occupy much of north-eastern Norfolk, lighter lands of sand, gravel and marl occupy the northern and western borders, and heavy land of chalky boulder-clay extends over much of central and southern Norfolk.

Large tracts of boulder-gravel, made up chiefly of flints, occur on Mousehold Heath, Norwich, at Poringland, near Holt, Fakenham, Dereham, and other places.

The coast formed of soft strata, except at Hunstanton, has been subject to great waste by the sea, aided by landslips. Blown sands fringe the coast in places north of Yarmouth, and near Wells and Burnham.

At Grimes Graves, near Weeting All Saints, neolithic flint-pits have been discovered. The flints in that neighbourhood along the Ouse Valley near Thetford, have indeed been utilized since palæolithic times; some implements having been fashioned from gravel-flints, others from flints taken directly from the Chalk. Gun-flints were until recent years manufactured at Whitlingham near Norwich, and there also flints were dressed for building-purposes. Many of the round church towers were built of gravel-flints, as there is no durable freestone suitable for corner work in the county.

Sea-side resorts: Cromer (broad sands, cliffs), Hunstanton (sands, rocks, cliffs of white and red chalk, sandstone), Mundesley (sands, cliffs), Runton (sands, cliffs), Sheringham (sands, cliffs), Wells-next-the-Sea (sands), Yarmouth (sands).

Northamptonshire. Map 22. Area 641,992 acres.

In this county the geological structure is simple. On the west a vale of Lias extends from the neighbourhood of Banbury to Daventry and Market Harborough. An upland region of Oolites stretches through the heart of the county from Brackley to Northampton, Rockingham and Peterborough; and a belt of Oxford clay occurs on the eastern margin from near Rushden to Peterborough. A great portion of the upland region and eastern portion is concealed by boulder-drift, which forms good wheat land. The Lias tracts especially constitute a grass country, famous as a hunting field. The Lower Lias clays are opened up in brickyards at Braunston, and they were traversed in the great Kilsby tunnel on the London and North-Western Railway, and more recently at Catesby on the Great Central Railway. The Middle Lias, with its rock-bed or marlstone on top, is a ferruginous limestone, and an important water-bearing stratum in the Northampton area. It is overlain by fossiliferous limestones and thick beds of blue clay belonging to the Upper Lias.

At the base of the Oolites the Northampton sands yield important beds of iron-ore near Towcester, Blisworth, Northampton, Wellingborough, Kettering, and Thrapstone. In some parts, however, as at Duston, the equivalent strata yield flaggy freestone. These beds, with overlying estuarine clays, occupy the Oolitic regions of the southern part of the county; while north-eastwards from Maidwell, north of Northampton, the division known as the Lincolnshire limestone is developed, and this forms the famous building-stones of Weldon, and the Barnack Rag near Stamford. Locally at its base is the Collyweston slate, a flaggy bed used for stone-tiles. At Wittering there is a chalybeate spa. The Great Oolite series comprises an Upper Estuarine series of coloured clays and sands, and of shelly limestones and clays, with the Cornbrash famous for fossils at Rushden and other places. The Oxford clay is well exposed at Peterborough.

Northumberland. Map 23. Area 1,289,756 acres.

This county is largely formed of Carboniferous rocks, extensively covered with drift deposits, and although much of the ground on the eastern borders is somewhat monotonous, it is diversified by the picturesque wooded river channels. The Lower Carboniferous rocks, including the equivalents of Lower limestone shales, Carboniferous limestone, and Yoredale rocks or Upper limestone shales, form one great series. They contain beds of workable coal at Scremerston, and other places, south of Berwick, and are also worked for lime-burning. Many fossils have been obtained at Lowick.

In the western part of the county the Cheviot Hills, which rise to 2676 feet in a tract of granite, are elsewhere formed largely of andesites, volcanic material of Old Red sandstone age. Traces of Silurian rocks occur on the Scottish borders, while the hills to the south-west are Lower Carboniferous, Carter Fell rising to 1815 feet.

Moorland tracts extend southwards to Haltwhistle and Allendale, where lead and zinc mines have been worked in the Lower Carboniferous group.

In the south-eastern part of the county we have the true Coal-measures forming the Newcastle coal-field. In this district the coal was used as fuel in the time of the Roman occupation, but it was not worked to any extent until the thirteenth century. Wallsend lies to the east of Newcastle, where the Roman wall ends on the north of the Tyne. Grindstones are manufactured to the north of the city.

Notable intrusions of igneous rock (mostly dolerites) in the form of sills and dykes appear in the Great Whin Sill, which extends from the neighbourhood of Haltwhistle to Dunstanburgh, Bamburgh, and the Farne Islands; and in the Acklington dyke which extends from the coast at Acklington inland to the Cheviot volcanic rocks.

Near Tynemouth, at Cullercoats and Whitley, there are remnants of Magnesian limestone.

Sea-side resorts: Alnmouth (sands), Bamburgh (sands and cliffs), Cullercoats (rocky), Tynemouth (sands, cliffs), Whitley-by-the-Sea (sands, rocks).

Nottinghamshire. Map 24. Area 539,752 acres.

In this county the strata outcrop from west to east in fairly regular belts. On the west the Nottingham coal-field appears at the surface in the Erewash Valley; it is the eastern portion of that of Derbyshire, and both are connected with the great Yorkshire coal-field. How far to the east and south-east the Coal-measures may extend is a subject of much practical importance. Coal-measures have been reached at Owthorpe on the south and at Collingham on the east. The beds are overlain unconformably by the Permian and newer strata. The Permian rocks comprise the Magnesian limestone, an important building-stone worked at Mansfield Woodhouse, where limestone and white and red dolomitic sandstones are obtained. The Magnesian limestone is burnt for lime at Mansfield, Bulwell, and other places, and overlying marls are employed for brickmaking.

The Bunter beds include soft and earthy sands much used for foundry purposes. They comprise also pebble-beds and pebbly sandstone, which extend from the cliff on which Nottingham Castle stands to Sherwood Forest and northwards between Worksop and Retford to Bawtry. This is a fine residential tract known as "the Dukeries." Keuper sandstones overlie the Bunter and are used as building-stone.

The eastern part of the county is for the most part clayey and agricultural. The Keuper marls extend north-eastwards and northwards from Trent Junction to Southwell and Newark, where the beds are largely worked for gypsum. Rhætic beds occur along the borders of the Lower Lias, and this latter formation, which is quarried for lime and cement at Barnstone, extends eastwards into the Vale of Belvoir. At Orston there is a chalybeate spa. Drift gravel and boulder-clay are found in various parts of the county; much valley-gravel occurs on the borders of the Trent, while the alluvium forms rich meadow-lands.

Oxfordshire. Map 3. Area 483,614 acres.

This county is formed of a series of Jurassic and Cretaceous strata. The lowest beds, those of the Lower Lias, appear in the upper parts of the valleys of the Cherwell above Banbury, and of the Evenlode above Charlbury. Shelly beds have been polished for marble at Banbury. The Middle Lias with the marlstone is well developed near Banbury, and the rock-bed is extensively quarried as a building-stone at Hornton near Edgehill, where it occurs as a brown and green ferruginous limestone. At King's Sutton and Adderbury it is an iron-ore that has been largely worked, and the same is the case at Fawler, near Charlbury. The soil is a rich brown friable loam. Next comes the stiff blue Upper Lias clay which borders the Oolites and occurs in the Windrush Valley above Burford. A boring made a little south of Burford was carried through the Lias and New Red rocks to the Coal-measures, which were reached at a depth of about 1200 feet.

The Oolites form the uplands, which extend from Burford to Woodstock, Chipping Norton, and Bicester. The Inferior Oolite series, including the Chipping Norton limestone, is found in some of the outlying hills and scarps on the north-west, but it is far thinner and less important than in the Cotteswold Hills. It contains sands as well as limestones, with fine examples of *Trigonia* and other fossils. The Great Oolite series extends over much of the Oolitic uplands, as a white limestone with marls, and with underlying freestone at Taynton and Milton near Burford. The white limestones are rich in corals and other fossils. Above comes the Forest marble, so named from the Forest of Wychwood north-east of Burford, where layers of shelly limestone were in old times polished for mantel-pieces. Near Kirtlington remains of the huge *Ceteosaurus* have been obtained.

Locally at Stonesfield the lowest beds of the Great Oolite consist of flaggy oolitic and sandy limestone, mined for stone-tiles, and known as the Stonesfield slate. These beds have yielded remains of mammals, reptiles, fishes, mollusca, plants, &c. The neighbourhood of the village of Stonesfield is riddled with shafts. The Cornbrash which overlies the Forest marble is as usual fossiliferous and is well exposed at Witney, Kidlington, Bicester, &c., and in faulted tracts at Islip, &c. The Oxford clay forms a belt of low-lying ground along the borders of the Thames from Lechlade to Bampton and Oxford, and to the north-east of the city, as at Otmoor. Large brickyards have been opened up near Oxford, where many ammonites and other fossils occur. The Corallian beds overlie the Oxford clay and have been quarried for stone (of poor quality) at Headington and Wheatley. Kimeridge clay succeeds and is to be seen at the base of Shotover Hill. Here Portland beds overlie, and are covered by Lower Greensand. Other tracts contain Portland and Purbeck beds, as at Garsington and Great Haseley; and Portland beds occur at Thame. The Lower

Greensand near Oxford is a mixed formation of sands with beds of ochre and fuller's earth, and some freshwater mollusca occur in the lower strata. Gault occurs at Culham and in the vale which extends to Tetsworth. The Upper Greensand outcrops in a minor scarp along the foot of the Chiltern Hills. These Chalk hills form a fine escarpment, extending from Goring and Whitchurch towards Stokenchurch, with, on their flanks, an occasional outlier of Reading beds and London clay, as at Nettlebed (607 feet), and on the lower part of the dip-slope, as near Caversham and other places. Along this slope to near Henley-on-Thames, tracts of clay-with-flints, brickearth and gravel are scattered over the Chalk surface. Valley gravels border the Thames from Bampton to Oxford and lower down along its course.

Oxfordshire contains little glacial drift except in the north-eastern part on the borders of Buckinghamshire.

Rutlandshire. Map 19. Area 97,273 acres.

The small county of Rutland consists wholly of Lias and Oolites. The Lias occupies the Vale of Catmoss, to the west of Cottesmore, and is a well-known hunting field. The lower beds of clay occur about Whissendine; while the brown rock or marlstone of the Middle Lias occurs around Oakham. The Upper Lias borders the ramifying Oolitic hills and is worked for bricks at Luffenham, Seaton and other places. The Northampton sands at the base of the Inferior Oolite occupy the hills about Uppingham and have yielded iron-ore locally at Cottesmore and Manton. The Lincolnshire limestone above yields a useful freestone at Clipsham, Casterton, and Ketton. Estuarine beds and Great Oolite limestone occur at Essendine, and boulder-clay and drift gravels are scattered over much of the area.

Shropshire. Map 25. Area 859,516 acres.

In this county there is great variety of geological formations and physical features. The Wrekin, a dome-shaped hill which rises to 1335 feet, has been claimed by Dr. C. Callaway as the oldest mountain in England; on its borders the gneiss of Primrose Hill and the schists of Rushton may represent some of the oldest known rocks, while the Wrekin itself is largely formed of rhyolitic lavas (Uriconian) of Pre-Cambrian age. Similar rocks occur at Caer Caradoc, and a granitoid rock is found at Cardington Hill. In the charming moorland regions of Church Stretton, the Longmynd is formed of purple slates, grits and conglomerate, also of Pre-Cambrian age, and these Longmyndian rocks occur in Haughmond Hill.

Flanking the Wrekin, Cambrian quartzites form the base of the Comley (Hollybush) sandstone, which yields *Olenellus* and *Paradoxides*, and above come the Shineton shales (Tremadoc) with *Dictyonema*.

West of the Longmynd rise the Ordovician rocks of the Shelve district; at the base the Arenig Stiper stones are formed of quartzite, with the overlying Llandeilo series of Meadowtown and the Bala series of Chirbury. Silver-lead and zinc-ores occur in this district, and barytes has been worked at Wotherton. To the east of the Longmynd is the famous region of Caradoc, where Ordovician rocks rest unconformably on the Cambrian and older rocks, and comprise the Hoar Edge grits, the Chatwall sandstones, and flags and shales, all belonging to the Bala series.

FIG. 14.—THE STIPER STONES.

Further east we find a succession of Silurian rocks (see Fig. 15), from the Llandovery to the Old Red sandstone. The gorge of the Severn between Buildwas and Ironbridge has cut through some of these rocks which extend to the south-west in a series of scarps and dales, including Wenlock Edge formed of Wenlock limestone. Fuller's earth occurs in the Wenlock shales and also in the lower Ludlow beds, and has caused landslips of the overlying rocks. The Upper Ludlow beds contain bone-beds with remains of fishes and of the crustacea *Pterygotus* and *Eurypterus.* The highest Silurian rocks include the Downton sandstone, with *Lingula cornea,* and tilestones equivalent to the Ledbury shales. They extend on the borders of the Old Red sandstone, and occur near Bishop's Castle and Ludlow.

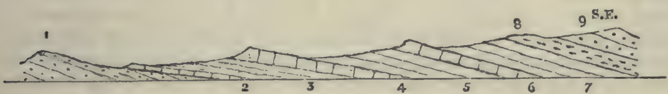


FIG. 15.—SECTION ACROSS THE SILURIAN ROCKS OF WENLOCK EDGE. (*Ramsay.*)

9, Old Red sandstone; 8, Ledbury shales and Downton sandstones; 7, Upper Ludlow beds; 6, Aymestry limestone; 5, Lower Ludlow beds; 4, Wenlock limestone; 3, Wenlock shale: 2, Llandovery beds; 1, Ordovician: Bala beds.

The Old Red sandstone occurs in Clun Forest and covers the ground between Bridgnorth and Ludlow. It contains patches of Coal-measures, capped by sheets of intrusive basalt (Dhu stone) in the Clee Hills. A small coal-field occurs at Leebotwood, south of Shrewsbury. The Carboniferous limestone and Millstone grit border that part of the Denbighshire coal-field which extends to Oswestry; the limestone being polished for marble near Llanymynech. They fringe the western parts of the Coalbrookdale coal-field which southwards overlaps on to the Old Red sandstone and joins the Wyre Forest coal-field at Bewdley. Thin representatives of Carboniferous limestone and Millstone grit occur at Farlow, N.W. of Cleobury Mortimer.

Permian breccias and sands occur at Alberbury and Shrewsbury, the breccias containing fragments of Carboniferous limestone. Bunter sandstones and pebble-beds occur over much ground in the north and east, as well as Keuper sandstones which are worked at Grinshill, the Hawkstone Hills and Market Drayton. Keuper marls occur at Wem and Whitchurch. These beds are extensively covered with shelly drift gravels, and boulder-clay, so that we see nothing of the Rhætic beds and little of the Lias. The Middle Lias is, however, exposed at Prees.

The drift contains granite from Criffel and Eskdale, and the sandy beds contain marine shells sometimes at high elevations, as at Gloppa near Oswestry (1120 feet). Some of the meres occupy shallow basins in the drift sands and gravels, which appear in esker-like knolls and ridges.

Somerset. Map 11. Area 1,043,485 acres.

This county is one of the most varied with regard to its geological formations and types of scenery. In West Somerset there are high moorlands formed mainly of Devonian slate and sandstone, thickly wooded in places. On Brendon Hills there are ironstone mines. Exmoor Forest with Dunkery Beacon (1707 feet), is the home of the red deer. The rocks stand out boldly on the coast at Culbone and between Porlock and Minehead, they also form the Quantock Hills, between Watchet, Taunton and Bridgwater. They are much faulted and folded, and here and there fossils have been found, more especially in some of the limestone bands. At Hestercombe, north of Taunton, a vein of granite has been observed. At Cannington Park a mass of Carboniferous limestone appears. This rock constitutes the chief part of the Mendip Hills from Frome to Bleadon and Uphill, and the Holmes islets in the Bristol Channel. The strata form a series of anticlines with the Old Red sandstone appearing in places, as north of Shepton Mallet and Wells and on Blackdown (1068 feet); and with eruptive rocks at Downhead, Wrington, &c. The Old Red sandstone is separated from the Carboniferous limestone by a belt of Lower limestone shales. The limestone is famed for its rocky crags and combes and caverns, notably the Cheddar Cliffs, Ebbor Gorge, the combes of Vallis and Nunney, near Frome, and the caverns of Cheddar, Wookey, Banwell, &c. Those of Cheddar have fine stalactites. The limestone appears at Weston-super-Mare, Clevedon, and thence to the Avon Gorge, also near Wrington, where Cleve and Brockley combes are famous. The Coal-measures are largely worked around Radstock, near Bristol and at Nailsea. The vale of Taunton, the slopes of the Polden Hills, and the lower grounds bordering the Mendips are composed of red sandstones and marls, with the Dolomitic conglomerate, a beach deposit formed of Carboniferous limestone, &c. Lead and zinc-ores have been worked on the Mendips, the former mainly from veins in the Carboniferous limestones, the latter in the Dolomitic conglomerate. Gypsum occurs in the red marls at Watchet and other places.

The Rhætic beds, formed of black shales and White Lias, with landscape marble, fringe the red marls and are overlaid by the Lower or Blue Lias. The Lower Lias is extensively quarried for flags and building-stone, lime and cement, at Street near Glastonbury, near Somerton, Watchet, Keynsham, Saltford, and many other places. Numerous fossils have been obtained, notably saurians at Street, and many ammonites at Keynsham, Watchet, and elsewhere. At Shepton Mallet there are beds of pale granular limestone. The Middle Lias with its fossiliferous rock-bed occurs at Glastonbury and Pennard Hill, and higher beds of Upper Lias with many fossils occur also at Glastonbury, and at Ilminster where numerous fossil fishes have been obtained.

The Inferior Oolite series, with the Midford sands as its base, extends from near Crewkerne by Ham Hill and Yeovil to Bruton and Doulting. The sands cap the isolated hills of Glastonbury Tor and Brent Knoll, and the Inferior Oolite again extends from near Frome, to Radstock and Bath, and forms the summit of Dundry Hill, famous for its ammonites and other fossils. At Ham Hill, with its Roman encampment, at Doulting and Dundry, the beds have yielded excellent freestones. Somerset, however, is especially noted for the Bath stone, quarried on Combe Down, and mined eastwards on the Wiltshire borders. This belongs to the Great Oolite, and it is separated from the Inferior Oolite by the Fuller's earth formation which contains valuable beds of fuller's earth at Midford and Wellow.

Above the Great Oolite is the Forest marble, a variable formation, of clay, limestone, and sand. It appears along the bold scarp, which extends from Templecombe by Wincanton to Frome, where the oolitic limestone is quarried for building-stone; and it outcrops at Charterhouse Hinton, where sands with masses of hard sandstone occur. The Cornbrash above, extends from Templecombe to near Frome; and the Oxford clay occurs on the eastern borders of the county in the vale south of Frome, formerly part of Selwood Forest. In the same neighbourhood the Gault and Upper Greensand of Penselwood, and the Chalk at Long Knoll (945 feet), extend into the county from near Maiden Bradley in Wiltshire. The Chalk with its fossiliferous basement-bed or Chloritic marl, and Upper Greensand occur at Chard.

The alluvium forms the flat meadow lands and moorlands of the Bridgwater levels and Sedgemoor, and peat is extensively dug between Glastonbury and Highbridge. The valley gravels of the Avon, near Bath, have yielded pleistocene mammalia, and other remains have been found together with palæolithic implements in caves and fissures bordering the Mendips from Wookey to Banwell and Uphill. Blown sands occur along the coast near Burnham, and raised beaches are met with near Weston-super-Mare. Sands with marine shells are found at Burtle and other places in the alluvial moorlands. No Glacial Drift occurs.

Bath is noted for its thermal waters, varying in temperature from 104° to 120°. They contain from 144 to 168 grains of mineral matter, chiefly sulphate of lime, per gallon. They also contain radium. They probably rise from the Carboniferous rocks at a depth estimated at 3500 feet. Chalybeate waters occur at Glastonbury, and sulphurous waters at Queen Camel.

Sea-side resorts: Burnham (sands), Clevedon (stony beach, cliffs), Minehead (pebbly beach, cliffs), Porlock (stony beach, cliffs), Watchet (rocks, cliffs), Weston-super-Mare (sandy, cliffs).

Staffordshire. Map 26. Area 749,601 acres.

In this county we have two important coal-fields, that of South Staffordshire or the Black Country, which extends from Dudley to Walsall and Cannock Chase, and that of North Staffordshire or the Potteries, with its adjunct the Cheadle coal-field, which is not of great commercial importance. In the South Staffordshire coal-field the strata are bent into anticlines with cores of Silurian rocks. Thus at Sedgely the beds from Llandovery to Ludlow are exposed; at Walsall and Great Barr, Llandovery to Wenlock, with the Woolhope (Barr) limestone yielding *Illænus barriensis;* and at Dudley the Wenlock (Dudley) limestone is exposed at Dudley Castle and the Wren's Nest, yielding many trilobites, corals, brachiopods, &c. The limestones are largely burnt for lime, and they have been extensively mined in the Dudley district. The Coal-measures in this same district are noted for the ten-yard seam, which is due to the coalescing of a number of seams elsewhere parted by shales and sandstones. This thick coal has been proved in deep borings and worked north of Birmingham. Here and there the coal has been invaded and burnt by intrusive sheets of basalt or dolerite; that known as the Rowley Rag at Rowley Regis has been extensively quarried for road-metal. In North Staffordshire the Coal-measures are much folded and faulted. In the lower strata the best coals are found, higher up there are coals and black-band or carbonaceous ironstones. Numerous bands of limestone occur in the upper strata, which yield entomostraca, *Carbonicola, Anthracomya* and fish remains. Grey marls in the black-band series are used for the manufacture of saggers and bricks, and at a higher horizon the red and mottled Etruria marls are largely used for brick-making and rough pottery. The highest known division is a mass of red sandstones and marls, named by Mr. W. Gibson the Keele sandstone series, and this contains limestones with *Spirorbis* and Coal-measure plants. The clays used for the best pottery are imported from Cornwall, Devon and Dorset.

Millstone grit and Lower Carboniferous rocks occur north-east of Biddulph and the Cheadle coal-field; and in this region white clays are found in pockets of the Carboniferous limestone on the Weaver Hills, and on the moorlands which extend eastwards into Derbyshire.

In the western part of the county there are Permian breccias at Enville, west of Stourbridge.

The central parts of the county are formed partly of Bunter and Keuper sandstones, with an extensive tract of Keuper marls, which yield gypsum at Uttoxeter, Fauld and Tutbury, and brine-springs at Stafford. Cannock Chase, which, extends into the South Staffordshire coal-field, is a picturesque, hilly and heathery tract of Bunter pebble-beds, the quartzite pebbles of which yield Ordovician and Silurian fossils. Bunter and Keuper sandstones border that coal-field from Lichfield to Birmingham, at Wolverhampton and Stourbridge. The Bunter stands out boldly at Abbot's Castle Hill and at

Kinver Edge, where artificial caverns have been excavated in the rock.

On Needwood Forest outliers of Rhætic beds occur, and here and elsewhere over the county there is much boulder-clay and drift-gravel.

Suffolk. Map 27. Area 952,709 acres.

This is a comparatively flat county with no conspicuous hills, but much of it consists of a plateau which rises from about 150 to 400 feet, and the main features lie along the lower courses of the rivers which drain into the North Sea. The Chalk forms the foundation of the entire county, if we except certain tracts beneath the Fenland near Mildenhall, where Gault and Kimeridge clay may be present. On the east and south-east the Chalk is covered by Eocene strata, by Thanet sands near Sudbury, and by Reading beds and London clay from Sudbury to Lowestoft and Gorleston. These Eocene strata are again overlain along the eastern borders by the Pliocene (Crag) series, which overlaps the Eocene and rests on the Chalk northwards by Halesworth and Beccles. Scattered irregularly over all these strata are accumulations of boulder-clay, brickearth, sand and gravel. The boulder-clay is a stiff, stony and chalky clay, the product of ice action, and this occupies much of central Suffolk, forming somewhat heavy land, good for wheat and beans. Along the eastern coast sands and shelly Crag beds prevail, and there we find light lands and many picturesque heaths and commons. In western Suffolk the Chalk is less thickly covered with Drift, and much of this is loose sand, apt to be wind-drifted, as near Brandon.

The Chalk is best exposed in the west. At Brandon many pits and shafts have been dug for flints to be used for the manufacture of gun-flints (now almost a lost industry) and for blocks for building-purposes. Other pits may be seen near Mildenhall, Newmarket, Bury St. Edmunds, and at Needham Market and Claydon, near Ipswich. The London clay is seen on the borders of the Stour, Orwell and Deben, and it contains septaria, which were formerly used for the manufacture of cement. The Crag formation is probably the most interesting, as it yields so many fossils. The oldest portion, the Coralline Crag, is best seen near Aldeburgh, Sudbourn and Orford. It consists of yellowish sandy marl and shelly and sandy limestone, with many mollusca, bryozoa or polyzoa, &c. The Red Crag, as its name implies, is a red shelly sand, with also numerous mollusca, and at its base a bed rich in phosphatic nodules and phosphatized bones and other remains. It is well seen above the London clay in the cliffs at Felixstow and Bawdsey, and in many inland localities, notably at Sutton, Hollesley, Butley and Chillesford. The still newer Norwich Crag occurs at Dunwich, Easton Bavent, Wangford and other places (see Plate 49). On the coast at Pakefield and at Corton the Cromer Forest bed series may be observed at the base of the cliffs. This includes gravelly beds with freshwater shells and mammalian remains, black peaty layers and a rootlet bed.

Overlying these deposits at Kessingland and Pakefield are glacial sands and pebble gravel and chalky boulder-clay. Similar beds occur to the north of Lowestoft; and at Gorleston and other places the sand contains fragmentary shells in abundance. Pebble gravel occurs also at Westleton, Halesworth and Henham. Later deposits formed prior to the present rivers occur at Hoxne and near Brandon, where palæolithic implements occur. The gravels bordering the present rivers also contain implements of this character along the valleys of the Lark and Ouse.

In a trial boring for coal at Stutton, a hard slaty rock, of Silurian or older age, was met with beneath the Chalk and Gault at a depth of 994 feet.

Sea-side resorts: Aldeburgh (shingle), Felixstow (sandy low cliffs), Gorleston (sands, cliffs), Lowestoft (sands and shingle, cliffs on south), Southwold (shingle and sand, low cliffs).

Surrey. Map 28. Area 485,128 acres.

Surrey occupies a part of the London Basin, with the Chalk hills of the North Downs rising to the south in the fine scarp which extends from Farnham along the Hog's Back to Guildford, where the Chalk is highly inclined, and eastwards to Dorking, Box Hill, Merstham and Caterham. Along the borders of the shallow basin the Thanet and Reading beds outcrop at Croydon, Ewell, Epsom and Leatherhead, and thence to the north of Guildford and Farnham, while the London clay occupies an undulating tract further north at Ockham, Malden, Surbiton, Upper Norwood, &c., with inlying Woolwich beds at Dulwich. Epsom is noted for its saline waters. The Bagshot beds, comprising sands and loams, occupy a large tract of picturesque fir-clad and heathy country from Esher, Weybridge and Chertsey, westwards to Woking, Bagshot, and the Chobham Ridges; and there is a small outlier at Wimbledon.

Along the borders of the Thames there are tracts of valley gravel and loam which extend to Mitcham and near to Croydon.

To the south of the Chalk range we find the diversified country of the Weald. The Upper Greensand, quarried for its firestone and hearthstone, near Godstone and formerly at other places, occurs along the base of the escarpment. Then follows a narrow vale of Gault clay worked for bricks at Merstham.

South of this we come upon the divisions of the Lower Greensand: the Folkstone sands dug near Godstone for glass sand and silver sand; the Sandgate beds, which yield fuller's earth at Nutfield and may be represented by pebbly beds (Bargate stone) near Godalming; and the Hythe beds, which include layers of Kentish Rag, siliceous limestone and chert. These form the crest of the Lower Greensand hills, as at Reigate, the pine woods of Abinger, Leith Hill and the high grounds of Hind Head, with the Devil's Punch Bowl, near Haslemere. A belt of Atherfield clay forms in places the base of the Lower Greensand, but it gives rise to no feature distinct from the Weald clay, which occupies a broad, undulating and well-timbered vale at the foot of the scarp, as at Ockley, Horley and Crowhurst. The Hastings sands rise over a small area in the south-eastern part of the county.

Sussex. Map 28. Area 933,269 acres.

In Sussex the geological formations outcrop in fairly regular sequence. In the north a considerable portion of the Wealden area is included. The oldest rocks exposed are the Purbeck beds, which occur along the summit of the anticline of the Weald, in a faulted tract which lies to the north-west of Battle. A deep boring at Netherfield, in Mountfield parish, was carried to a depth of 1,905 feet into Oxford clay, through Purbeck and Portland beds and Kimeridge clay. Valuable beds of gypsum were found in the Purbeck beds. Elsewhere these strata comprise grits, shales and limestones, some of the shales being highly bituminous. The natural gas which has been found at Heathfield appears to escape from the thin sandstones in the Lower Wealden strata and from the Purbeck beds. The Kimeridge clay which occurs at some depth below is looked upon as the chief source of natural gas and oil, as it contains thick bands of bituminous shale. It may be that stores of gas are held in the overlying Portland sands, and that the gas is partly fed from this source.

The Hastings sands form a varied area of bold hill and deep valley, and while the strata are largely of a sandy nature there is also much clay and shale. Lignite also occurs in places. The beds are seen in the cliffs near Hastings, and there are sandstone quarries here and there inland, as near Heathfield, in the Ashdown sands, which occur over Ashdown Forest, and rise in Crowborough Beacon to a height of 800 feet. The Wadhurst clay above contains much iron-ore, worked until 1828 for the Wealden furnaces, and up to 1720 the chief source of our iron. The Tunbridge Wells sands are more regularly bedded, but the sands are often so fine and interbedded with clay that water lies on the flat surfaces of hills and the roads are sticky and muddy in wet weather. Despite this, the Hastings sands form an attractive residential county, as near Mayfield, Heathfield, Crowborough, Balcombe, &c. The overlying Weald clay forms a tract of lower ground, much of it heavy, but lightened by sandy veins and bands of Sussex marble with *Paludina*. Blocks of this rock are used for causeways.

The Lower Greensand, a series of sands, sandstones and clays, forms the picturesque region which extends from Midhurst to Petworth, Fittleworth, Pulborough, Storrington, Hassocks Gate, Ringmer and the north of Eastbourne. Pleasant tracts of heath and woodland characterize this region.

The Gault clay forms a belt of lowland to the south, with the Upper Greensand above. Higher still rise the South Downs, a range of Chalk hills extending from the cliffs of Beachy Head westwards by Lewes, Ditchling Beacon, the Devil's Dyke, Steyning, Chanctonbury Ring and Amberley to the hills north of Goodwood Park. Along this course, and especially at Lewes, many Chalk pits are met with. Chalk cliffs extend from Beachy Head by Seaford to Brighton. Near Wilmington the figure of a giant or Long Man of Wilmington has been cut through the turf on the Chalk scarp. West of Brighton the low grounds which border the sea for some distance inland, are formed of brickearth and chalky gravel (Coombe rock). These beds conceal a tract of Reading beds, London clay and Bagshot and Bracklesham beds, which occupy a syncline at Chichester. Reading beds occur at Newhaven. The London clay contains hard bands of calcareous sandstone, which form the Bognor Rocks. The Bracklesham beds are shown on the foreshore at low tide west of Selsey Bill, at Bracklesham Bay, where many fossils are to be obtained. Here, too, are beds of drift containing erratic blocks of granite, greenstone, &c., brought by floating ice. These beds are overlain by marine clay and by estuarine mud with plant remains at West Wittering. Remains of mammoth and rhinoceros also occur. The Coombe rock is newer, and is due to subsequent erosion of the Chalk tracts at a time when the surface of the Chalk, as pointed out by Mr. C. Reid, was frozen and thereby rendered impervious.

Sea-side resorts; Bexhill-on-Sea (sands), Bognor (sands and shingle), Brighton (shingle, sand at low tide, chalk cliffs to east), Eastbourne (shingle and sand, cliffs), Hastings (sands, rocks, cliffs), Littlehampton (sandy and pebbly), St. Leonards (sands and shingle), Seaford (shingle, chalk cliffs), Selsey (shingle and sand), Shoreham (sand and shingle), Worthing (sands and shingle).

Warwickshire. Map 29. Area 577,462 acres.

While most largely an agricultural county, there is a small coal-field to the north between Tamworth and Bulkington, and on the eastern margin of it there is a belt of ancient rocks, including the Caldecote Volcanic series, which is Pre-Cambrian, and the Cambrian quartzite of Hartshill, near Nuneaton, which is largely quarried and distributed as a road metal. In the upper part is a limestone band with *Hyolithes* and *Kutorgina*. The overlying Stockingford shales contain *Obolella*, *Agnostus* and *Dictyonema*.

A considerable portion of the county is occupied by the New Red rocks and by the Lias, and these formations are partially concealed by Drift deposits of gravel, sand and boulder-clay. The age of some of the Red rocks is under discussion, and it has yet to be decided how much of the area that has been regarded as Permian, near Coventry, may belong to the Coal-measures or to Trias. Bunter beds occur to the west of Sutton Coldfield.

In the Keuper sandstones of Warwick saurian and fish remains, and in the upper beds at Shrewley some mollusca have been obtained. At Leamington there are saline waters. The Keuper marls occupy a large area, and they are succeeded by the Rhætic beds, which, however, are nowhere well exposed. They extend over a part of the old Forest of Arden. The Lower Lias is developed at Rugby, where the Blue Lias limestones are worked for lime and cement. This is the case also at Stockton, near Southam, Harbury, Kineton and Stratford-on-Avon. These beds include limestones, which range from the lowest portion with *Ammonites planorbis* or *A. Johnstoni*, as at Stratford-on-Avon, to higher beds with *A. Bucklandi*, as at Rugby. Fine examples of the crustacean *Eryon* are found in the lower beds. Above the series of limestones are clays yielding many fossils, as at Fenny Compton, where ammonites and belemnites abound, and at Cherrington, where many corals have been found.

The Middle Lias forms the crest of Edge Hill, and yields good building-stone; it occurs also at Burton Dasset. The basement portions of the Inferior Oolite series appear in the county near Long Compton, overlying the Upper Lias. Valley drifts yielding Pleistocene mammalia occur along the borders of the Avon.

Westmorland. Map 8. Area 500,906 acres.

This picturesque and mountainous county includes the south-eastern portion of the Lake District. Ambleside, with Rydal Water and Grasmere, Bow Fell (2960 ft.) and Langdale Pikes, lie to the west; Helvellyn (3118 ft.), Ullswater and Haweswater, and the granite mass of Shap Fells (1853 ft.) lie to the north-west among the Borrowdale volcanic series, with a mass of Skiddaw slates west of Shap, and a fringe of the Coniston limestone series on the south. Beyond this, on the borders of Windermere, at Bowness, eastwards to Stockdale and Bannisdale, and southwards from Kendal to Kirkby Moor and Kirkby Lonsdale, Silurian rocks occupy the land.

Lower Carboniferous rocks with scars of limestone extend from the west of Kendal to Kirkby Lonsdale, and north-eastwards from Lowther Castle, south of Penrith, to Ravenstonedale and Mallerstang, south of Kirkby Stephen. On the eastern side of the Vale of Eden they occur over Milburn Forest, Dufton Fell (2137 ft.) and Stainmore Forest (1689 ft.); a range of Fell country with Millstone grit overlying the Carboniferous limestone in the south-eastern part, and an intrusive sheet of dolerite, part of the Great Whin Sill, overlooking the Vale of Eden below Milburn Forest and Murton Fell (2206 ft.).

The Vale of Eden from Kirkby Stephen to Appleby is occupied by Permian red sandstones and conglomerate (brockram), with Bunter Sandstone on its eastern side, and faulted belts of Ordovician and Silurian rocks at Dufton and Keisley.

Much drift occurs, and blocks of Shap granite from Shap Fell have been scattered over the heights of Stainmore. At Shap Wells there are saline waters.

Wiltshire. Maps 11 and 14. Area 880,248 acres.

This is almost wholly an agricultural county which extends over a wide area from near the head of the Thames on the north to Cranborne Chase on the south, and it includes many geological formations. The oldest strata are those exposed in the north-west from Bradford-on-Avon to Malmesbury. Lias occurs in the deep valley near Box, with overlying Inferior Oolite and Fuller's earth. The Great Oolite series comprises the famous Bath freestone, which is quarried at Bradford-on-Avon and more largely at Box. To the north and north-east the stone is less important, as at Yatton Keynell, Castle Combe. It is overlain at Bradford-on-Avon by the Bradford clay, a fossiliferous band yielding the crinoid *Apiocrinus*, or Pear Encrinite, and many brachiopods. Above is the Forest Marble, comprising oolitic limestones, shales and sandy beds, well exposed near Corsham and Malmesbury. The Cornbrash, a fossiliferous rubbly limestone, overlies, and this outcrops at Trowbridge, near Chippenham, and Malmesbury. The Oxford clay, with sandy Kellaways beds at base, forms a great clay vale which stretches from near Trowbridge through Melksham, Chippenham, past the famous fossil localities of Kellaways and Christian Malford to the old Forest of Braydon, Brinkworth, Minety and Cricklade. Saline waters have been encountered at various points in this tract, as at Melksham Spa and Purton near

Cricklade. The Corallian beds form a scarp overlooking the clay vale. They comprise marls and oolites with brown iron-ore at Westbury, the coral bed of Steeple Ashton, freestones and fossil beds at Calne, where also the lower beds of calcareous grit yield *Ammonites perarmatus* and other fossils. The beds appear also at Wootton Bassett and Highworth. The Kimeridge clay succeeds and forms a belt of clayland with many dairy-farms from near Westbury to near Seend, and from Wootton Bassett to Swindon, where the clay is extensively dug for brickmaking, and yields many saurians and other fossils. It occurs also at Semley in the Vale of Tisbury. Portland sands and stone-beds overlie and furnish famous building-stone at Tisbury and Chilmark, mostly calcareous sandstone, but there are fossiliferous limestones here, near Potterne, and at Swindon, where also hard sandstone is quarried. The Purbeck beds comprise clays and limestones, the latter worked near Teffont Evias in the Vale of Wardour. The beds yield fish-remains and many other fossils, notably a crustacean, the *Archæoniscus*. At Swindon the Purbeck beds rest irregularly on the Portland rocks. There are traces of Wealden beds at Dinton in the Vale of Wardour.

The Lower Greensand oversteps the earlier formations. It is thinly represented by sandy strata near Dinton. It appears again west of Devizes as ferruginous sands, yielding iron-ore at Seend. The Gault clay occurs uniformly at the base of the Upper Greensand and Chalk, on the margins of the Vale of Wardour, near Mere and Stourton, at Edington near Westbury, and thence along the foot of the downs above Swindon. It is worked for brickmaking. The Upper Greensand likewise forms a belt bordering the Vale of Wardour, rising into picturesque high ground at Fonthill Abbey, and furnishing locally a green sandstone used for building. Inliers appear at Bower Chalk to the south. Northwards it forms a broad belt of sandy uplands from near Mere, by Maiden Bradley to Warminster, a region famous for remains of sponges and other fossils. It extends along the escarpment by Lavington, occupies an elevated plateau with deep sandy lanes at Devizes, forms the foundation of the Vale of Pewsey, and fringes the Chalk escarpment to Swindon.

The Chalk occupies a considerable tract in Wiltshire, including the undulating plateau of the Marlborough Downs and Salisbury Plain, with their ancient monuments of Avebury and Stonehenge, formed largely of greywethers—relics of Tertiary sandstone. Fine Chalk hills occur in the south, notably at Winklebury Hill, on the borders of Cranborne Chase.

To the south-east of Salisbury there are tracts of Reading beds and London clay on Clarendon Hill and near Downton, with overlying Bagshot beds near the borders of the New Forest. Reading beds also occur in outliers near Great Bedwin. Palæolithic implements have been found at Knowle Farm, on the borders of Savernake Forest. Patches of oolitic gravel occur in the vale near Cricklade and along the borders of the Avon from Kellaways to Limpley Stoke. Other drifts occur near Salisbury. There is a Pleistocene brickearth with mammalian remains at Fisherton, and palæolithic implements occur in the low-level river-gravels, while Eolithic implements occur in the plateau drift at Alderbury, and also at Brinkworth, near Wootton Bassett.

Worcestershire. Map 29. Area 480,560 acres.

In this county the most prominent features are formed by the older rocks of Malvern. The core consists of Archæan gneiss, bordered on the south-west by Cambrian Hollybush sandstone and quartzite, Malvern black shales with *Olenus*, and overlying grey shales with *Dictyonema*. Silurian rocks from the Llandovery to the Ludlow occur on the western side, and in these many trilobites and other fossils have been found.

Permian breccias, formed of ancient scree material, mostly igneous rock, appear on the Abberley and Clent Hills (1028 ft.).

In the Lickey Hills (900 ft.) we again find Cambrian quartzite, overlain by Llandovery sandstone, while in the same district there occur at Barnt Green Pre-Cambrian volcanic grits and flaggy beds, probably Uriconian.

The Old Red sandstone occurs on the west of Malvern and extends to Tenbury. The passage-beds from the Silurian through the Downton sandstones and Ledbury shales have been well exposed at Ledbury.

The Coal-measures of Bewdley, part of the Wyre Forest coal-field, occur to the north-west, and a part of the South Staffordshire coal-field enters the county south of Dudley. To the east of this tract, and faulted against the Malvern range, are the Triassic rocks. The soft Bunter sandstones and the pebble-beds occur near Kidderminster, and on the Lickey Hills, where the quartzite pebbles are partly of Cambrian and partly of Llandovery age.

The Keuper sandstones have been quarried at Ombersley and other places. The overlying Keuper marls occupy a large area, and they yield the famous brine springs derived from rock-salt at Droitwich, and also at Stoke Prior.

Rhætic beds have been traced along the borders of the Lower Lias, as near Upton-on-Severn and Dunhampstead.

The limestone-beds at the base of the Lias are quarried in many places, as at Strensham, Croome D'Abitot, Cleeve Prior, &c. The higher clayey beds are very fossiliferous near Evesham and Pershore, and they are covered in places by gravel, in this famous market garden and fruit region.

Bredon Hill is an outlier of Inferior Oolite based on Upper and Middle Lias, and much faulted. The Oolite is there shattered and weathered. The valley drifts have yielded mammalian remains, and in some localities marine shells, which may have been derived from glacial drifts.

Yorkshire. Maps 18 and 30. Area 3,882,848 acres.

Geologically this county is best divided into two portions, East and West Yorkshire, with a line of division through the vale of York. This division does not correspond with the topographical areas of West, North and East Riding, neither does it correspond more than approximately with the above-mentioned maps. Nevertheless, it is useful to adopt it.

WEST YORKSHIRE.

The main mass of this western part is formed of Carboniferous rocks, a portion of the Pennine chain: including the Carboniferous limestone with numerous outliers of Millstone grit rising up in high moorlands and fells, with rugged scars and weathered surfaces of limestone, with numerous pot-holes or "sinks," as Helm Pot north-east of Ingleborough. These rocks stretch from the borders of Teesdale with its Great Whin Sill and inlier of Silurian, across Lune Forest and Bowes Moor to Swaledale and Wensleydale, with its waterfall of Aysgarth Force. Westward the rocks extend to Sedbergh, where again Silurian rocks appear, and there are inlying tracts of the Coniston limestone series (Ordovician). Dent is famous as the birthplace of Sedgwick.

Eastwards Bow or Baugh Fell, to the south Whernside (2414 ft.), and again Ingleborough (2373 ft.) and Penyghent (2273 ft.) are mountainous outliers of Millstone grit. Near Ingleton there is a small tract of Coal-measures, and at Horton-in-Ribblesdale a faulted inlier of Silurian and Ordovician. To the south again lies Settle, famed for its picturesque scars of limestone and its Victoria cavern, with mammalian remains probably older than the local boulder-clay. On the high moorlands eastward lies Malham Cove, whence issues the river Aire from an underground supply fed from Malham Tarn. To the south-west is the Forest of Bowland. Thence eastward by Gisburn to Skipton the rocks belong to the Carboniferous limestone series. Beyond lies the broad and elevated moorland region of the Millstone grit, which forms a belt on the margin of the Yorkshire coal-field, extending from the west of Sheffield across Penistone Moors to Holmfirth and Blackstone Edge, and through Keighley to Ben Rhydding and Ilkley, Harrogate, Pateley Bridge, where the Brimham rocks are noteworthy, to near Leyburn and Richmond. Here are famous health resorts, Harrogate being noted for its sulphurous and chalybeate waters.

The coal-field extends from Sheffield, through Barnsley, Silkstone, Huddersfield and Wakefield to Bradford and Leeds. Wortley, to the south-west of Leeds, is noted for its fire-clay, which is manufactured into glazed bricks and tiles and fire-bricks. Eastwards the coal-field lies buried beneath Permian and Triassic rocks. The great unconformity between the Permian and older rocks is shown by the fact that the Magnesian limestone series extends on these eastern borders from South Anston to Tickhill, Doncaster, Pontefract and Ferrybridge on the Coal-measures, to Tadcaster, Knaresborough (with its "petrifying springs"), Ripon and Bedale on the Millstone grit, to the Tees Valley, where it rests on Lower Carboniferous rocks.

The Vale of York from Bawtry through Doncaster and Thorne to Selby and York is occupied by New Red rocks, Bunter and Keuper, but both are for the most part concealed by coverings of glacial drift and alluvium.

EAST YORKSHIRE.

In this area are included the East and part of the North Riding, from the Vale of York near Thorne, to the River Tees below Croft, with Yarm and Middlesbrough.

The Vale of York is a belt of New Red rocks with Bunter and Keuper sandstones on the western side and Keuper marl on the east of Thorne, Selby, York, Boroughbridge and Middlesbrough; but these red rocks are thickly covered in places by alluvial and glacial drifts, including extensive deposits of lacustrine brick-clays.

Below the mass of red and variegated Keuper marls, red and white sandstone with red marl, rock-salt and gypsum have been proved below Eston Junction and at North Ormesby, east and south-east of Middlesbrough. Rhætic beds have locally been traced near Northallerton. Further east there rises the great mass of Lias and Oolites which form the East Yorkshire Moors. The northern scarp, capped by Estuarine beds of the Lower Oolites from the east of Northallerton to near Guisbrough, forms the Cleveland Hills, along the margin of which the famous iron-ore is obtained from the Middle Lias. In higher beds at the base of the Oolites (Dogger series) the magnetic iron-ore of Rosedale is worked in one of the deep inlying valleys in the central part of the moorland region.

The Hambleton Hills (1289 ft.) form the scarp of the Corallian rocks east of Thirsk, and extend to the Tabular range above Pickering and near Hackness. On the south side of the Vale of Pickering the Corallian rocks are well seen near Malton, which is noted for a chalybeate spa.

The Oolites form a fringe along the eastern side of the Vale of York to South Cave and the borders of the Humber. Here the Upper Cretaceous strata have transgressed across their outcrops, so as to largely conceal them in places.

The best region for the study of the Lias and Oolites is undoubtedly along the fine coast-line between Redcar and Filey. At Redcar there are reefs of the Lower Lias limestones. From Saltburn to Whitby the cliffs are of Middle and Upper Lias. Whitby is famed for its Upper Lias ammonites, the supply of which being unequal to the demand, fossils from Lyme Regis are sold also to visitors. Jet, too, is not so abundant. Alum has been largely obtained from the shales, as at Saltwick. Hawsker Cliffs show the Estuarine beds and Dogger overlying the Upper Lias, which in descending order comprises the Alum shale with *Ammonites communis*, the slaty shales with jet-beds and *Am. serpentinus*, and shales below with hard nodules and *Am. annulatus*. Lower still is the Middle Lias (ironstone-beds), with *Am. spinatus*, and (sandy series) with *A. margaritatus*. Robin Hood's Bay exhibits in the cliffs at low tide a foreshore of Lower Lias shales with *Am. capricornus*, *A. Jamesoni* and *A. armatus*. Boulder-clay also occurs. The Peak Cliffs on the south, and Blea Wyke display the Estuarine beds with coaly seams on top, also the Dogger, with much iron-ore, resting on sandy (Blea Wyke beds) and Upper Lias.

Scarborough Castle stands on the Corallian (calcareous grit with doggers) and Oxford clay with Kellaways rock, faulted down on the east side so that lower beds of Cornbrash and Upper Estuarine appear westwards on the north side of the headland.

White Nab, south of Scarborough, forms the northern horn of Carnelian Bay, where the cliffs of boulder-clay have yielded many carnelians. The southern horn of the bay is formed by Osgodby Nab, beyond which is Cayton Bay. Here the Lower Calcareous grit caps the Oxford clay, the full thickness of which is shown, with Kellaways beds and Cornbrash at base.

Red Nab (Calcareous grit over Oxford clay) forms the headland south of Cayton Bay, beyond which is Gristhorpe Bay, where the Upper Estuarine beds, with lignite bands and many remarkable irregularities in deposition are observable; the Grey limestone, the Middle Estuarine beds, and the Millepore bed are also to be seen. Here many plant-remains have been obtained.

Southwards again higher beds of Corallian and Oxford clay and Cornbrash appear above the Estuarine series. The Corallian beds, capped by reddish-brown boulder-clay, extend to Filey Brigg—the Brigg being a reef of hard Lower Calcareous grit, surmounted by a bed with large spheroidal concretions or doggers. Filey Bay is fringed by the Kimeridge clay which extends beneath alluvial deposits over much of the Vale of Pickering. Towards Speeton the Kimeridge clay is overlain without unconformity by nodular phosphatic beds, probably representing the Portland beds, and clays and shales with marine fossils which yield *Belemnites lateralis*, and higher up *Bel. jaculum* and *Exogyra sinuata*. These are marine equivalents of the Purbeck-Wealden and Lower Greensand. Red Chalk, representing Gault and Upper Greensand, overlies the Speeton clay, beyond which the Chalk forms the fine cliffs with sea-caves of Bempton (300 ft.) and Flamborough Head, and the Wolds of East Yorkshire, which above West Heslerton rise to 620 feet.

The south-eastern portion of the county which extends over Holderness to Spurn Head (a spit of blown sand and shingle) is thickly covered with glacial drift, shelly sands and boulder-clay. Some of the shelly beds at Bridlington were at one time regarded as Crag.

Kirkdale Cave is a hyæna-den in the Corallian limestone near Kirkby Moorside on the north side of the Vale of Pickering.

Sea-side resorts: Bridlington (sand and shingle, chalk cliffs) Filey (sands, rocks, cliffs), Hornsea (sand), Redcar (sands), Robin Hood's Bay (rocks, cliffs), Runswick (sands, cliffs), Saltburn-by-the-Sea (sandy, rocks, cliffs), Sandsend (sands, cliffs), Scarborough (sands, cliffs), Whitby (sands, cliffs), Withernsea (shingle and sand).

Isle of Man. Map 7. Area 145,325 acres.

The Isle of Man is formed chiefly of a mass of slates, grits and flags, grouped together as the Manx series, equivalent to the lower part of the Skiddaw slates of the Lake District, and probably of Cambrian age. They rise to a height of 2034 feet at Snaefell, and form rugged precipitous cliffs on the coast. No definite organic remains have been found in them. As Mr. G. W. Lamplugh has pointed out, the rocks have been greatly folded, and in places so much broken and affected by earth movements that fragments of hard rock have been rounded so as to form a crush-conglomerate. These broken-beds are well seen in

Sulby Glen, between Peel and Ramsey. Numerous igneous dykes penetrate the rocks, and they are affected also by the intrusion of the masses of granite at Foxdale and Dhoon, the bordering Manx rocks being more or less metamorphosed. Metalliferous veins occur, with argentiferous galena and blende (sulphide of zinc). The lead-mines of Foxdale and Laxey are the most important.

Carboniferous rocks with basement conglomerate at Langness occur at the southern end of the island at Castletown and Poolvash (Poylvaaish) where limestones and shales, and beds of black marble, are found. Goniatites, brachiopods and other fossils may be obtained. Volcanic rocks occur in the series at Scarlet Point. At Peel there are beds of sandstone and conglomerate which are probably of the age of the basement Carboniferous. They contain derived Ordovician fossils.

Permian and Triassic rocks have been proved in borings beneath the Drift in the northern part of the island. That region is thickly covered with glacial sand, gravel, and boulder-clay, while a raised beach occurs at the Point of Ayre and adjacent coast. The greater portion of the island exhibits evidence of glaciation, and the drift deposits have helped to render fertile the glens in the central parts.

Recent deposits contain remains of the Irish Elk.

Sea-side resorts: Castletown (rocky), Derby Haven, Douglas (sand and cliffs), Peel (rocks and cliffs), Ramsey (sands, cliffs and rocks), Port Erin (sands, cliffs).

WALES.

Anglesey. Map 31. Area 175,836 acres.

This island county, which nowhere attains any considerable elevation is for the most part a gently undulating region, very largely formed of slates, grits, and schists. The quartz schists of Holyhead Mountain (719 feet), and the contorted schists of the South Stack islet are well known, and rocks of this nature occupy much of the western coast, and appear in belts in the central and eastern parts. These schists are of Pre-Cambrian age.

Serpentine (Mona marble) occurs to the north of Rhoscolyn, on Holyhead, and on the adjacent mainland; while a belt of granitic rocks traverses the island south of Llanerchymedd, and a patch appears at Parys Mountain, south of Amlwch, where copper-ore, ochre and umber have been worked.

Ordovician grits and slates, in places fossiliferous, elsewhere much broken and crushed, and Silurian rocks (Llandovery), occur on the north coast at Amlwch and westwards to Carmels Point. Ordovician rocks are again met with north of Beaumaris. In the northern tract there are also green schists and slaty rocks partly made up of volcanic materials, that may be of Pre-Cambrian age. Old Red sandstone (or basement Carboniferous conglomerate) occurs at Dulas Bay and southwards towards Llangefrie. Carboniferous limestone with fossils, occurs to the east, also on Puffin Island, on the mainland adjoining, and on the borders of the Menai Strait, south of the Tubular Bridge. Coal-measures and Permian rocks extend through Malldraeth Marsh, and the former fringe a portion of the coast opposite Carnarvon.

Everywhere the island presents evidences of glaciation, and there is much boulder clay and drift gravel and sand, which constitute the more fertile areas.

Blown sand occurs here and there in large tracts between Holyhead and the Menai Strait.

Sea-side resorts: Amlwch, with Bull Bay (sands and rocks), Beaumaris (stony and sandy shore), Benllech Bay, west of Red Wharf Bay (sands), Cemaes (cliffs).

Brecknockshire. Map 32. Area 475,224 acres.

Ordovician rocks occupy the north-western part on the borders of the Elan Valley, to Llanwrtyd Wells.

The Builth Wells consist of saline, chalybeate, and sulphurous waters, and they issue from the Llandeilo Flags with igneous rocks, which cross the Wye to the north-west of the town.

From Builth to Llangammarch, and to the south-west, Silurian rocks outcrop in a belt. The main mass of the interior is formed of Old Red sandstone from Talgarth and Brecknock, eastwards over the Black Forest (2624 feet) to Crickhowel, southwards to the Brecknock Beacons (2907 feet), and south-westwards to Fforest Fawr or the Black Mountains with Brecknock Van (2632 feet). On the southern borders of the county there is a scarp of Lower Carboniferous rocks and Millstone grit, disturbed at the head of the Neath Valley, and portions of Coal-measures occur at Brynmawr and along the Tawe Valley at Drim.

The Llangammarch Wells are situated at an elevation of about 600 feet on the slopes of the high moorlands of the Mynydd Eppynt range. The waters contain much chloride of sodium, also chlorides of calcium and magnesium, but they are noted for the chloride of barium, which they hold in small quantities. The Llanwrtyd Wells (about 800 feet above sea level) are sulphurous and chalybeate waters.

Glacial drift occurs in many places, and there is much gravel in the broad valleys.

Cardiganshire. Maps 31 and 32. Area 440,630 acres.

In this mountainous county we have an extensive area of Ordovician and Silurian grits, shales and slaty rocks, generally folded and often inverted. Graptolites appear to be the more abundant fossils. Much of the land is boggy, and there are many small lakes. Plynlimmon (2468 feet) stands on the borders of Montgomeryshire, and is formed of grits which occupy a syncline.

Tregaron is the chief town of a mining district, where lead, copper and zinc ores have been obtained. Boulder-clay, sand and gravel extend over much of the country. Agates, jaspers, and other pebbles obtained from the beach at Aberystwith are polished for sale.

Sea-side resorts: Aberaeron (pebbly beach), Aberporth (sands, rocks), Aberystwith (shingle, sand and rocks), Borth (sands), Cardigan (near mouth of Teifi), Gwbert (sand, rocks, cliffs), New Quay (sand and boulders, cliffs), Traethsaith (sands, cliffs), Ynyslas-on-Sea (sands).

Carmarthenshire. Map 32. Area 587,816 acres.

In this county a large tract of Ordovician slates, sandstones and grits, and possibly also Silurian rocks, extend from the borders of the Teifi at Newcastle Emlyn, southwards to Carmarthen and Llandilo.

Llandeilo gives name to the Llandeilo Flags, which include occasional limestones, and yield trilobites. such as *Ogygia Buchi* and *Asaphus tyrannus*, and other fossils. Gold was worked by the Romans at Gogofau, near Llanpumpsaint. Lead-ore has been worked near Carmarthen.

Llandovery, to the north-east of Llandeilo, gives name to the Llandovery beds, the base of the Silurian, which locally have yielded lead-ore. To the south of Llandilo, and fringing the base of the Old Red sandstone, is a narrow belt of highly inclined micaceous flags or tilestones. Eastwards, the Old Red sandstone rises up in Carmarthen Van (2632 feet), and extends westwards to Ferryside and Laugharne. These rocks are bordered by uplands of Carboniferous limestone and Millstone grit, which form part of the Black Mountains, and stretch from the neighbourhood of Llandebie to the coast near Kidwelly, reappearing at Pendine on the north of Carmarthen Bay. Coal-measures occur here, while eastwards they extend from Kidwelly to Llanelly, and north-eastwards to Ammanford, forming the western portion of the main coal-field of the Swansea region.

Glacial drift is found at various elevations, and the broad flat valleys are occupied by gravels and alluvium.

Blown sands stretch on either side of the estuary of the Towy, forming Laugharne Sands on the west and Pembrey Burrows on the south-east.

Sea-side resorts: Ferryside (sands), Llanstephan (sands, cliffs), Pembrey (sands), Pendine (sands, cliffs).

Carnarvonshire. Map 31. Area 361,097 acres.

Cambrian rocks occupy a considerable part of this county from Bangor to Bethesda, with the Penrhyn slate quarries on the borders of Nant Francon; and they occur south-eastwards to Llyn Padarn and Llyn Peris, to the north of which lie the Llanberis and Dinorwic slate quarries. Thence the rocks extend to the coast near Penygroes station.

The higher Cambrian (Tremadoc) slates appear between Portmadoc and Criccieth, to the south-west of Tremadoc; and other Cambrian rocks occur on the south-eastern horn of the Lleyn promontory. The south-western portion of that promontory and Bardsey Island are formed partly of metamorphic rocks, schists and igneous rocks of Pre-Cambrian age, with also sedimentary rocks and rhyolitic lavas of the Ordovician system.

Ordovician rocks, with many volcanic and intrusive rocks, extend over the eastern portion of the county, including the more mountainous tracts, with Snowdon (3560 feet), Y Glyder fawr (3279 feet), Moel Siabod (2860 feet), the neighbourhood of Capel Curig, and Bettws-y-Coed, Dolwyddelan, Beddgelert and the western side of the Pass of Aberglaslyn, with Moel Hebog (2566 feet). In the Lleyn promontory there are notable quarries at Nevin of granite-porphyry. Similar rock also occurs at the Rivals (Yr Eifl); while at Penmaenmawr there is enstatite-diorite, which is extensively quarried.

Carboniferous limestone occurs at the Great and Little Ormes

Heads, where the *Productus giganteus* is abundant; and also south of the Tubular Bridge.

Evidences of glacial action are conspicuous in the district around Snowdon in perched blocks, roches moutonnées, moraines and other scattered drift deposits (see Fig. 7, p. 33). The cliffs west of Criccieth are formed of boulder-clay, and in places there are contorted beds with fine gravel, sand and silt. On Moel-y-Tryfan, south of Carnarvon, there is drift with marine shells at an altitude of over 1300 feet.

Blown sand occurs on the Ormes Heads, likewise west of Carnarvon, at the entrance to the Menai Strait, and on the coast at Pwllheli and St. Tudwal's Road, on the west of Tremadoc Bay. At Trefriw there are chalybeate waters.

Sea-side resorts: Bangor and Carnarvon (on Menai Strait), Criccieth (sandy and stony, cliffs), Llandudno (sands and shingle, limestone cliffs), Llanfairfechan (sands), Nevin (sands, cliffs), Penmaenmawr (sands), Pwllheli (sands).

Denbighshire. Map 31. Area 423,477 acres.

This is largely a moorland country, formed of Silurian grits, sandstones, flags, and shales, which extend from the borders of the Conway at Llanrwst and Pentre Voelas eastwards to Denbigh and Llangollen. The rocks belong chiefly to the Wenlock series (Denbighshire grits and flags). Ordovician rocks enter the southern part of the county in the valley above Bettws-y-Coed, in the Fairy Glen, and at the Conway Falls; and extend from near Yspytty Evan, Cerrig-y-Druidion and the Berwyn Mountains (2716 feet) south-eastwards to Llanrhaiadr, which is noted for its fine waterfall. Carboniferous rocks occur on the east, with a basement conglomerate, referred sometimes to the age of the Upper Old Red sandstone.

Carboniferous limestone outcrops east of Llangollen and forms a fine scarp, the Eglwysegle Rocks, overlooking the famous Vale of Llangollen. Further east lies the coal-field of Ruabon, Wrexham, and Minera, with coal-mines and iron-works.

New Red rocks occur along the eastern margin of the county. Further north the Vale of Clwyd lies mainly in Denbighshire, with a belt of Carboniferous limestone on the west and Silurian rocks bordered by Carboniferous limestone on the east. The Vale itself is occupied by New Red rocks and drift, and the red rocks and occasional fringes of Carboniferous limestone are faulted on the east against the Silurian strata. Coal-measures appear near St. Asaph and Abergele. The Carboniferous limestone here, as elsewhere, has numerous caves, as at Cefn and Plas Heaton on the western side of the Vale of Clwyd, where remains of mammoth, rhinoceros, hippopotamus, &c., have been found. Lead, silver, and zinc-ores occur in the limestone near Minera.

Sea-side resorts: Abergele with Pensarn (sands), Colwyn Bay (sands).

Flintshire. Map 31. Area 164,050 acres.

This is largely a mining county, the Flintshire coal-field extending from the northern end of the Vale of Clwyd near Prestatyn, and along the Dee Valley by Holywell, Flint, and Mold to Hawarden. The cannel-coal and oil-shale of Leeswood are noted; fire-clay is also worked in places.

West of Mold the Carboniferous limestone series with the Millstone grit rise up in Halkin Mountain and extend to the high ground above Prestatyn. The "Millstone grit," which in North Flintshire immediately overlies the Carboniferous limestone, comprises beds of chert, which are used in the Staffordshire potteries. These chert-beds pass elsewhere, as observed by Mr. A. Strahan, into fine-grained sandstone and quartz-grit; and the group is overlain by the Holywell shales which contain *Posidonomya*, *Aviculopecten*, and *Goniatites*. Higher still is the Gwespyr Sandstone, which is regarded as equivalent to the Gannister or Lower Coal-measures of Lancashire. To the north-west of Holywell, lead and zinc-ores are worked, the principal mines being those of Talacre and Talargoch. At Holywell there is a healing spring known as St. Winifred's Well.

That portion of the Vale of Clwyd which lies in Flintshire, near Rhyl and St. Asaph, is mainly formed of New Red rocks covered with glacial drift. On the eastern side of the Vale, near Tremeirchion, in the Carboniferous limestone at Ffynnon Beuno and Cae Gwyn, there are caves with Pleistocene mammalia and palæolithic implements, and these remains occur in deposits overlain by boulder-clay.

Sea-side resorts: Prestatyn (sands), Rhyl (sands).

Glamorganshire. Map 32. Area 516,959 acres.

In this county we have the great mass of the South Wales coal-field, extending from Swansea to Neath, Maesteg, Pontypridd, Merthyr Tydvil, and the Rhymney Valley. The northern borders of the basin are formed by the Millstone grit, which appears near the faulted head of the Neath Valley, and near Merthyr Tydvil. In the interior of the coal-field the main features are the fine wooded and moorland hills of Pennant grit, which separates the Lower from the Upper Coal-measures. Caerphilly Castle is a prominent object on the southern borders of the district, north of Cardiff.

The coals are bituminous on the east, and anthracitic on the west. On account of the deep valleys the coal has in many places been worked by levels driven into the hillsides. The southern boundary of the coal-field is marked by the Millstone grit and Carboniferous limestone series, which here form far less prominent features than on the north.

The Gower promontory is a picturesque region with its cliffs of Carboniferous limestone, its fine sandy beaches, and open country

FIG. 16.—SECTION ACROSS THE SOUTH WALES COAL-FIELD (*E. Hull*).
A, Coal-measures; B. Millstone Grit C, Carboniferous Limestone Series; D, Old Red Sandstone.

extending from the Mumbles to Langland, Caswell, and Oxwich Bays and Worms Head. Caves with mammalian remains occur at

Paviland, Bacon Hole and other places. The ossiferous deposits are newer than the raised beaches and older than the local glacial drift.

A belt of Upper limestone-shales, and chert-beds with radiolaria, occurs at Bishopton, separating the Carboniferous limestone from the Millstone grit and Coal-measures to the north. Old Red sandstone, and even a trace of Silurian rocks, appear in the central part of Gower.

In the southern part of the county, south of Bridgend and Cardiff, the Vale of Glamorgan is a fertile agricultural region formed largely of Lower Lias. The Carboniferous limestone is exposed in places on the coast near Porth Cawl, Southerndown, and St. Brides, with also Old Red sandstone near Cowbridge, while to the east of Llandaff Silurian rocks appear. Red marls and Dolomitic conglomerate also occur in the Vale of Glamorgan along the southern margin of the coal-field near Cowbridge, St. Fagans, and at Sully Island, where bands of magnesian limestone are met with.

The Rhætic beds which form passage beds between Keuper and Lias, are well shown in the cliffs between Penarth and Lavernock. The upper part comprising grey marls and limestones, the central and main portion black shales with *Avicula contorta*, &c., and the lower part grey and tea-green marls which merge into the red and variegated Keuper marls. Traced westwards we find sandy beds, quarried for building-stone near Bridgend, and including near Pyle red marly beds on the horizon of the Upper Rhætic formation.

The Lower Lias is largely worked for hydraulic lime and cement at Bridgend, while more especially in the early part of last century at Aberthaw, the beach pebbles of argillaceous Lias limestone were locally burnt or exported to other districts for the manufacture of hydraulic lime. Fine cliffs of these limestones fringe the coast westwards to Dunraven and Southerndown. There the lower beds of Lias are conglomeratic, and pale granular limestones, known locally as the Sutton Stone, occur at the base.

Considerable deposits of glacial drift: sands, gravels, boulder-clay, and earthy boulder gravel are found near Cowbridge, St. Fagans, and northwards in the coal districts. Fine hillocks of blown sand occur near the mouth of the Ogmore at Candleston Castle, and north-westwards at Kenfig, along the coast of Swansea Bay, and also in Oxwich Bay.

Sea-side resorts: Caswell Bay, Langland Bay and Mumbles (sands, rocks, fine cliffs), Penarth (stony beach, cliffs), Porthcawl (sands, rocks), Southerndown (sandy beach, rocks, cliffs).

Merionethshire. Map 31. Area 427,810 acres.

In this county a great expanse of Cambrian rocks stretches from the neighbourhood of Festiniog, where the slates of the Lingula flags are extensively quarried, and Maentwrog where the Rhaiadr-Du (or Black Cataract) is a notable waterfall, across a mountainous tract of Harlech grits to Barmouth and Dolgelly. On these southern borders the Lingula flags again occur, and we have an auriferous belt which has been profitably worked near Dolgelly, while near Barmouth manganese ore has been obtained. In this region an occasional lava is found, and there are many intrusive igneous rocks.

Other eruptive rocks, with many interbedded masses, occur in the Ordovician which fringes the mass of Cambrian strata in what is known as the Merioneth anticline.

Aran Mowddwy (2970 feet) forms part of the Ordovician volcanic range, which extends to the south of Dolgelly and rises up in Cader Idris (2929 feet), where the volcanic ash-beds have been reckoned as over two thousand feet thick. Southwards from Dinas Mowddwy to the coast at Towyn and Aberdovey the Ordovician strata are free from volcanic beds. Near Towyn lead and copper-ores have been worked. On the north Moelwyn (2527 feet), Cynicht (2370 feet), and Manod Mawr (2166 feet), and on the east the Arenig range (2800 feet), are largely volcanic. Beyond lies Bala with its picturesque lake, and the Bala limestone which is largely quarried for lime-burning. A synclinal belt of Silurian rocks further east crosses the Dee Valley and extends to the north of Corwen.

Glacial drift, river gravels and alluvium are among the later deposits. Much blown sand borders the coast, forming the links below Harlech Castle, and continuing further south towards Barmouth, and again at Aberdovey. A diatomaceous earth has been observed at Llyn Arenig Bach.

Sea-side resorts: Aberdovey (sands, rocks), Barmouth (sands), Harlech (sands), Towyn (sands).

Montgomeryshire. Map 31. Area 510,111 acres.

Ordovician and Silurian rocks occupy the greater part of this county. The former rocks extend from the Berwyn range on the north with its bands of felsite and andesite, through Hirnant and Llanfyllin to Welshpool; they appear at Criggion, among the Breidden Hills; and at Corndon Hill with its laccolite of dolerite, east of Montgomery. Ordovician rocks again form a belt on the south-west from Machynlleth to Llanidloes and the borders of Plynlimmon, the source of the Severn. Through the central portion the Silurian rocks extend in a syncline from the neighbourhood of Lake Vyrnwy (which supplies its waters to Liverpool) in an irregular tract to Tarannon, Llanfair, Welspool, Newtown. Montgomery, and the Long Mountain, and southwards to Kerry Hill on the borders of Clun Forest, where Old Red sandstone is met with.

Lead, silver, and zinc ores are worked near Newtown and Machynlleth, and there are slate quarries at the latter place.

Glacial and alluvial deposits occur over considerable areas.

Pembrokeshire. Map 32. Area 395,151 acres.

This is a boldly undulating county, with a picturesque and diversified coast-line. The region of St. David's contains some of our oldest rocks, the Archæan granitoid rock (Dimetian), which is seen also on Ramsey Island; and volcanic rocks (Pebidian) which form the foundation of the old cathedral city. These rocks are fringed by Cambrian strata, which have yielded the large trilobites *Paradoxides*, and other fossils. Another tract of Cambrian lies to the north-west of St. David's.

Much of the county to the north of Haverfordwest and Narberth, and from St. David's Head to the borders of the Teifi near Cardigan is Ordovician, with many igneous rocks at Fishguard and Newport, on the Precelley Hills (1760 feet), and elsewhere. Some of the decomposed basaltic rocks, as near Little Newcastle, are water-bearing and give rise to springs.

The southern portion of Pembroke is a folded series in which Silurian, Old Red sandstone and Carboniferous rocks appear in belts. The shores of Milford Haven are for the most part Old Red sandstone; Pembroke, Carew Castle, Tenby and Gowan's Head are Carboniferous limestone, and Caldy Island exhibits both Carboniferous limestone and Old Red sandstone with the intermediate Lower Limestone shales. The coast at Tenby is remarkably picturesque, and the limestone exhibits many folds there and at Stackpole near Gowan's Head. North of Tenby is the Pembrokeshire coal-field, the western end of the great South Wales coal-field, which extends to the shores of St. Bride's Bay. The coal is anthracitic, and the strata are contorted.

Glacial drift occurs here and there, and blown sand fringes Freshwater Bay south of Milford Haven.

Sea-side resorts: Amroth (stony beach, cliffs), Broad and Little Haven (sands, cliffs), Fishguard and Goodwick (sands, cliffs), Manorbier (pebbly and sandy beach, cliffs), Milford Haven (stony beach), Newport (sands, rocks, and cliffs), St. David's, Caerfai (sands, cliffs), Saundersfoot (sands, cliffs), Tenby (sands, limestone rocks, and cliffs).

Radnorshire. Maps 31 and 32. Area 301,164 acres.

In this picturesque and hilly county Ordovician rocks occur at Rhayader on the west, and in a disturbed tract which, with many igneous rocks, extends through Llandrindod to the Wye Valley north of Builth. The Llandrindod Wells, which are situated in an open moorland region at an elevation of about 700 feet, are chalybeate, saline, and sulphurous waters. The Llandeilo Flags which occur on the north of Builth yield the trilobite *Ogygia Buchi* and other fossils. Silurian rocks occupy the heart of the county, extending over Radnor Forest through New and Old Radnor, where graphic granite, quartz felsite, and dolerite occur, to Presteign and Knighton. Eastwards the Silurian rocks are bordered by the Old Red sandstone.

Glacial drifts are met with in various places, and alluvial deposits occupy the valleys.

SCOTLAND.

Aberdeenshire. Maps 33a and 33b. Area 1,251,451 acres.

A highland county embracing some of the wildest and grandest scenery; it also comprises extensive tracts under cultivation. The rougher tracts, which westwards rise into the Grampians, are formed of schists, with great intruded masses of granite, such as the red granite of Peterhead, and the grey granite of Aberdeen which is quarried at Rubislaw. South of Peterhead, the Buller of Buchan is a hollow formed by the erosion of granite inside the sea-cliff, the entrance to which is through a sea-cave. In rough weather the waters are greatly agitated within the hollow. The Aberdeen granite extends to Ballater and Balmoral, and forms the mountains of Lochnagar (3768) and Ben Macdhui (4296 feet). Old Red sandstone occurs at Strath Bogie above Huntly and at Turriff.

The fertile character of the eastern tracts is due partly to the extensive coverings of Drift, in places one hundred feet thick, and consisting of boulder-clay and other clays, sands, and gravels; and also to the excellent system of farming. The drifts are of interest in containing relics of formations not preserved otherwise in the north-east of Scotland, such as the Pliocene (Crag) deposits, and the Chalk, and other Cretaceous strata as at Moreseat. Gravel ridges or Kames form the Kippet Hills by the Loch of Slains.

Blown sands overlie peat in the Links at Aberdeen, and extend northwards.

Sea-side resorts: Aberdeen (sands, cliffs), Cruden Bay (cliffs).

Argyllshire. Map 33b. Area 2,092,458 acres.

This is a land essentially of Highland schists, traversed by countless dykes of Tertiary basalt—especially in the region south-west of Loch Awe and the district of Cowal. There is, however, considerable diversity in the formations represented, though some occupy a very restricted area. The Island of Lismore is formed of limestone, possibly Pre-Cambrian, in which no fossils have been found: slates occur at Ballachulish and Easdale.

Ben Cruachan (3689 feet) forms part of a large granite area: the Ross of Mull is likewise formed of granite.

In the vicinity of Oban and on Kerrera the Old Red sandstone is represented, and the conglomerates with large boulders are well seen in the cliffs at Dunolly and Dunstaffnage. Associated with this formation there are extensive tracts of andesite. There is a small area of Carboniferous rocks near Campbeltown. Schists, with here and there blown sands, occupy the greater portion of the Mull of Kintyre, and practically the whole of Jura, Islay, Colonsay, Gigha, Iona, Coll and Tiree (see p. 38).

The rugged promontory of Ardnamurchan is formed of gabbro, like the Cuillin Hills of Skye, and the same rock forms a core at Ben More (3172 feet) in Mull.

Mull is largely formed of Basalt, with Tertiary leaf-beds at Ardtun, overlain by old river gravel with chalk flints. Lower Lias occurs near Tobermory and elsewhere. Fingal's Cave, in Staffa, is noted for its cliffs of columnar basalt. Basalt occupies a part of Morven, on the borders of the Sound of Mull; and there, as well as in Mull, there are Cretaceous sandstones.

Sea-side resorts: Ardrishaig (on Loch Fyne), Dunoon, Inellan (Firth of Clyde), Oban (Firth of Lorn), Tighnabruaich (Kyles of Bute—mostly with stony beaches and low cliffs).

Ayrshire. Map 33b. Area 729,186 acres.

In this county the geological structure is diversified and somewhat complex by reason of faulting. In the southern part the Ordovician rocks extend from near Ballantrae to the district of Carrick, forming a part of the Southern Uplands. Portions of a great granite mass appear at the head of Loch Doon. The Ordovician strata are faulted in this region—the southern great boundary fault of the midland valley stretching north-eastwards from near the mouth of Loch Ryan. Numerous subsidiary faults traverse the region near Girvan, amid tracts of Silurian, Old Red sandstone, and Lower Carboniferous, with volcanic rocks. The Lower Carboniferous strata form an irregular and broken belt around the Coal-measures with ironstones of Ayr and Kilmarnock, and here again we meet with igneous rocks. Andesites of Lower Carboniferous age extend on the north from Ardrossan to Wemyss Bay, and inland. New Red rocks (Permian or Trias), with volcanic beds in places, occur on the coast near Ballantrae and inland east of Ayr. There is much blown sand on the coast from Ayr northwards by Troon and Irvine to Saltcoats. Ailsa Craig (1097 feet), off Girvan is an islet of riebeckite-granite.

Sea-side resorts: Ardrosssan (sands, rocks), Ayr (stony and sandy), Ballantrae (rocks, cliffs), Barassie (sand), Girvan (stony beach and sands), Largs (stony beach, cliffs), Salt coats (sands, rocks), Troon (sands, cliffs)—on the Firth of Clyde.

Banffshire. Map 33a. Area 412,258 acres.

This is largely a Highland county stretching southwards along Glen Avon, a tributary of the Spey to the granite region of Cairngorm (4084 feet).

There the cairngorms have been obtained from veins of decomposed fine-grained granite. Schists of diverse character, with some limestones, occupy much of the country from the coast at Banff and Macduff inland by Keith.

A large mass of granite occurs to the south-west of Dufftown, rising in Ben Rinnes (2755 feet). Serpentine is found to the west of Portsoy. Old Red sandstone occurs at Gamrie south of Troup Head, and far inland at Tomintoul.

Extensive deposits of drift occur and give rise to more cultivated tracts in the lower lands. The boulder-clay at Blackpots, west of Banff, has yielded many derived fossils.

Sea-side resorts: Banff and Macduff, Cullen, Portsoy (sandy and stony beach, cliffs).

Berwickshire. Map 33b. Area 296,362 acres.

In this border county the oldest rocks are the Silurian of the coast between Burnmouth and Eyemouth, St. Abb's Head and Fast Castle, and they extend inland to the borders of the Lammermuir Hills.

The Old Red sandstone with andesites, occupies the central parts by Greenlaw and across a part of the Lammermuir Hills on the north, appearing also on the coast at St. Abb's Head and Eyemouth.

The lowest Carboniferous rocks, the Calciferous sandstone series or Tuedian, occupy the Tweed Valley and spread over a considerable tract from Coldstream to Greenlaw and Duns. These together with higher Carboniferous rocks, belonging to the limestone series, also appear in the fine cliffs from Berwick northwards to Burnmouth.

Sea-side resorts: Berwick (sands, rocks and cliffs), Burnmouth (cliffs).

Buteshire. Map 33b. Area 139,440 acres.

In this island county, which embraces Bute and the Cumbraes, Arran, Holy Isle, Inchmarnock and Pladda, schists with numerous dykes of basalt predominate; but volcanic rocks of Lower Carboniferous age occur in places, and at Millport, on Great Cumbrae, both Old Red sandstone and Carboniferous are met with.

The fossiliferous Clyde Valley beds which occur on the Kyles of Bute, comprise clays which contain Pleistocene shells. These have a northern character, comparable with that of Greenland, and include *Pecten islandicus. Panopæa norvegica, Cyprina islandica, Saxicava rugosa*, &c. (see Plate 50).

The clay is worked at Kilchattan, in Bute, for brick-making.

Arran has been classic ground for the geologist since the days of Hutton. The dominant feature, Goat Fell (2735 feet), is granite, which has protruded through the schists that occupy much of the northern part of the island. Old Red sandstone and Lower Carboniferous rocks appear in the central parts at Sannox Bay and near Brodick Bay, while in the southern half of the island, on the eastern borders, and in the north at the Cock of Arran there is red Triassic sandstone. This has been quarried at Corrie and Brodick. Igneous rocks, quartz-porphyry and basalt appear in the centre and south, and a large volcanic vent, with agglomerate, south of Machrie Water, has proved to contain remnants of Rhætic, Liassic and Cretaceous strata, a fact made known by the late W. Gunn.

Sea-side resorts: Rothesay in Bute (cliffs), Millport in Great Cumbrae (rocks, cliffs); Brodick, Corrie (cliffs), and Lamlash, in Arran.

Caithness. Map 33a. Area 438,878 acres.

This is a dreary looking region of moor and morass, redeemed by a grand coast line, the cliffs rising to three hundred feet and more.

Schists occupy the western and south-western portions of the county, with masses of granite, one of which forms the Ord of Caithness, while a larger tract extends from Kinbrace towards Reay.

The main portion of the county is formed of the Old Red sandstone which constitutes the fine cliffs all round the coast from Berriedale and Lybster to Wick, Duncansby Head, Dunnet Head and Thurso. Thurso has been the centre of the Caithness flag industry, to some extent a decaying industry, inasmuch as artificial pavements have checked the export trade. The town is famed as the home of Robert Dick, who so assiduously collected the fossil fishes found in the flags which naturally pave the foreshores and rise up in the rugged cliffs. Many of these fossils are found in a highly bituminous condition, and Hugh Miller used the soft material in old times for sealing letters. Holburn Head, west of Thurso, is a weird headland with a grand stack of rocks, while awful chasms formed along joint-planes in the strata, extend inland from the coast.

The fine and prominent mountains of Morven (2313 feet) and the Maiden Pap (1587 feet) are formed of Old Red sandstone resting on schists.

Much boulder-clay and extensive peat-mosses occur over the county.

Sea-side resort: Thurso (sands and cliffs).

Clackmannanshire. Map 33b. Area 30,477 acres.

This small county is mainly formed of Coal-measures, as at Alloa, and of Lower Carboniferous rocks at Culross. The northern part is an upland region on the southern slopes of the Ochil range.

Dumbartonshire. Map 33b. Area 154,542 acres.

This county extends into the Highland borders near Ben Vorlich (3092 feet), and thence southwards it includes a broad neck of schists, bordered by Loch Long on the west and Loch Lomond on the east, with Gareloch between.

Old Red sandstone appears at Craigendoran, and in a belt from near Helensburgh to the shores of Loch Lomond. South-east of Helensburgh there are Lower Carboniferous rocks, and again as we approach Dumbarton we find Old Red sandstone as well as Lower Carboniferous rocks and andesites, which form the Kilpatrick Hills. Dumbarton Castle stands on a rock of volcanic agglomerate. There are mines of coal and iron stone in the neighbourhood of Kirkintilloch.

Sea-side resorts: Helensburgh, and Kilcreggan (cliffs) at the mouth of the Clyde.

Dumfries-shire. Map 33b. Area 680,217 acres.

This is largely a county of Silurian rocks, including a part of the Lowther Hills in the north with Queensberry (2285 feet), and with infoldings or eroded anticlines of Ordovician strata. The district forms an essential part of the Southern Uplands, and it includes the fossiliferous tract of Dobb's Linn, in Moffatdale, rendered famous by the researches of Prof. Lapworth. It is drained by the waters of Nithsdale, Annandale, Moffat, and Eskdale, which trench the Silurian rocks, while the Nith rises far away to the north among the mass of the Ordovician rocks. Along both the Nith at Thornhill and the Annan below Moffat and Beattock, there are New Red rocks, regarded as Permian. Special interest in these strata was aroused by Sir William Jardine's folio work entitled *The Ichnology of Annandale, or Illustrations of Footmarks impressed on the New Red Sandstone of Corncockle Muir.* These red rocks, which comprise sandstone and breccia with volcanic rocks, are largely concealed by Drift, but red sandstones are quarried for freestone at Dumfries, and they appear also at Annan.

Ecclefechan stands on Lower Carboniferous rocks, which extend eastwards to the Esk Valley, where coals are worked at Canonbie, and are bordered on the north by Old Red sandstone and andesites.

At Sanquhar, on the north-west, there are coal-mines in the Coal-measures; and at Wanlockhead, on the borders of the Leadhills, there are lead mines in the Ordovician strata. Moffat is noted for its sulphur waters, and Hartfell Spa for chalybeate waters.

On the southern margin of the county, east of Gretna Green, is the Solway Moss, where peat has been extensively dug.

Edinburghshire (or Midlothian). Map 33b. Area 231,724 acres.

This county stretches southwards to the Ordovician grits and shales of the Moorfoot Hills, which lie to the south of the faulted boundary of the great Midland Valley.

The Coal-measures, with "flat coals," stretch southwards from Musselburgh and Dalkeith, and are bordered by Lower Carboniferous rocks, which being in places highly inclined, yield the "edge coals." These extend westwards to Portobello and Leith, and south-westwards to West Calder, where oil-shale occurs. In the shales of this lower division, as at Wardie, Newhaven, many fish-remains and other fossils have been found. In overlying strata at Craigleith and Granton the sandstones yield famous building-stone. At Burdiehouse, south of Edinburgh, the limestones contain ostracods, and many fish and plant-remains.

The volcanic rocks (basalt and dolerite) of Arthur's Seat (822 feet) and Salisbury Crags, of Calton Hill, and the Edinburgh Castle rock, belong to Lower Carboniferous times.

Southwards and southwestwards from the city the Old Red sandstone, with masses of andesite, and occasional patches of Silurian, rise to form the Pentland Hills.

Boulder-clay and other relics of the "Great Ice Age" are met with over much of the county, and on the coast at Musselburgh and Leith there are links of blown sand.

Sea-side resort: Portobello, on the Firth of Forth.

Elginshire (or Moray). Map 33a. Area 304,606 acres.

The southern part of this county, formed of Highland schists, is traversed by one of the grander of Scottish rivers, the Findhorn, which, from Relugas to near Forres, flows through a most picturesque rocky gorge of schists and Old Red sandstone. It is a river whose notable floods of 1829 were recorded by Sir Thomas Dick Lauder.

Westwards of its mouth are the famous Culbin Sands, which overwhelmed, towards the end of the seventeenth century, some of the more fertile tracts of Moray. Blown sands occur also along the shores of Burghead Bay.

Eastwards through Elgin there is a tract of Old Red sandstone, bordered on the north by the Triassic sandstones, which have yielded reptilian remains. Rocks of both ages are quarried, but the Old Red sandstone yields the finer freestone. The newer rocks form the cliffs from Burghead to Lossiemouth.

The Drifts are in places of special interest, as at Linksfield Rhætic fossils were long ago observed. Elsewhere boulder-clay and gravels cover great part of the lowlands, and extend in places over the uplands.

The lower part of the Spey traverses the eastern side of the county.

Sea-side resort: Lossiemouth (stony and sandy beach, and cliffs).

Fifeshire. Map 33b. Area 314,952 acres.

In this county there is a broad tract of Old Red sandstone and volcanic rocks in the north. The sandstone which has been quarried at Dura Den, a defile north of Pitscottie, joining the River Eden east of Cupar, is noted for the fossil fishes *Bothriolepis*, *Holoptychius*, &c. This tract is separated by the Howe of Fife from the southern area of Lower Carboniferous rocks, which extend from Dunfermline to St. Andrews, and contain the great volcanic masses of the Lomond Hills (1713 feet), and eastwards those of Largo Law (965 feet) and other prominent heights. The Lower Carboniferous rocks are worked for coal at Kirkcaldy; they also yield oil-shales. The sandstones are quarried for building-stone in many places, and the limestones are quarried for lime-burning. The limestone of Burntisland has yielded many fossil fishes, ostracods, plants, &c.

Coal-measures occupy the surface at Dysart and Leven, and there is much Drift.

Blown sands fringe the coast from Tayport to the Links of St. Andrews.

Sea-side resorts: Aberdour (sands, rocks) and Burntisland (sands, rocks), on the Firth of Forth; Ferry Port (sands and cliffs) and Newport (rocks), on the Firth of Tay); St. Andrews (sandy and rocky, cliffs).

Forfarshire. Map 33b. Area 560,087 acres.

This is in part a Highland county, extending northwards through Glen Clova into the Grampian region of schists, and to the granite, west of Kincardine. The more cultivated tracts lie on the Old Red sandstone which occupies the main portion of the county; it has yielded many remains of large crustaceans *Eurypterus*, *Pterygotus*, and *Stylonurus*. Volcanic rocks of this age form the Sidlaw Hills, and extend to the coast near Montrose. Glacial drift covers considerable areas, and blown sands fringe the coast from Carnoustie to Broughty Ferry, east of Dundee.

Sea-side resorts: Arbroath (sands and rocks), Broughty Ferry (sands), Carnoustie (sands and rocks), Montrose (sands).

Haddingtonshire (or East Lothian). Map 33b. Area 173,298 acres.

In this county there is a varied assemblage of Old Red sandstone, Carboniferous and volcanic rocks; with belts of Ordovician and Silurian rocks in the Lammermuir Hills, which rise to the south, Says Law (1749 feet) being the highest point. Andesitic lavas of Lower Carboniferous age extend around Drem junction, while North Berwick Law (512 feet), a part of the Garlton Hills, the rock on which Dunbar Castle stands, and the Bass Rock (350 feet) are formed of materials (basalts and trachytes) which may have filled volcanic vents. The volcanic rocks constitute fertile agricultural land.

Coal is worked in the Lower Carboniferous rocks.

Sea-side resorts: Dunbar (cliffs), North Berwick (rocks and cliffs, with links to west).

Inverness-shire. Maps 33a and 33b. Area 2,616,498 acres.

In this grand county there is no great variety of geological formations on the mainland, excepting among the Highland schists which occupy the chief part of the rugged and mountainous land.

The Monadhliath mountains to the north-west of Kingussie rise to upwards of three thousand feet, while Glen More or the Great Glen—with the Caledonian Canal extending through Lochs Linnhe, Lochy and Ness—traverses for the most part the schists.

The dominant features are formed by the great granite masses. Cairn Toul (4241 feet) rises east of Kingussie and is a part of the mass to which Cairn Gorm and Ben Macdhui belong. Ben Nevis (4406) is another mass to the south-west of the county, and minor tracts occur here and there.

Old Red sandstone occurs at Beauly and Inverness; it extends over Culloden Moor, and is met with on the eastern side of Loch Ness.

Glacial drifts occur over much of the region and present many features of interest. Thus in the parallel roads of Glen Roy (Lochaber) to the east of Loch Lochy, there are ancient lake-terraces, the highest beach being 1155 feet above sea-level, and they were formed when ice, during the glacial period, dammed up the waters in the glen.

In the Outer Hebrides, Harris, a part of the Long Island, and joined to Lewis, is reckoned a part of Inverness-shire. This and most of the islands to the south are formed of gneiss. The Shiant Isles belong to the Skye regions of basalt, while St. Kilda is formed partly of gabbro and granophyre, also Tertiary igneous rocks.

Many of the Inner Hebrides are included in Inverness-shire. Raasay is formed in part of gneiss at the northern end, and Rona is formed entirely of that rock. Torridon sandstone is seen at Brochel Castle further south in Raasay, and the adjacent ground is formed of terrace-like tracts of this rugged and picturesque rock. The southern parts of the island are formed of Jurassic rocks, Lias and Oolites, well developed in the grand cliffs on the eastern side, where also a small tract of red Triassic marls and conglomerate appears. Volcanic rocks, granophyre and basalt occupy much of the interior, and appear on the western and southern coasts; Dun Caan is formed of basalt.

Pabba is formed of Lower Lias shales with many fossils. Scalpa is chiefly formed of Torridon sandstone with Middle Lias on the east, and some traces of Cretaceous strata have lately been found.

Skye is mostly formed of basalts with gabbro forming the rough and rugged Blaven and the Cuillin Hills of which Scuir na Gillean (3167 feet) is the highest peak, while the Red Hills of conical form are shaped out of granophyre. Torridon sandstone occurs in Soay and Sleat, and schists are developed along the south-eastern shores of the promontory. At Broadford there is a broad belt of Lower Lias limestones, sandstones and shales; and various Jurassic rocks, as high as the Oxfordian, occur thence towards Strathaird, along the coast from Portree to Loch Staffin, and again at Uig and elsewhere. Tertiary lignite has been dug on a small scale in the so-called Portree coal-mine. Diatomite is worked north of the Storr Rock. Durness limestone is met with to the south-west of Broadford, and it has been polished as marble.

Canna is largely formed of basalt; Rum of Torridon sandstone, gabbro and granophyre; Eigg of basalt, with a turretted mass of pitchstone which rises up in the Scuir; and Muck is formed of basalt.

Sea-side resorts: Broadford, Kyle Akin, and Portree in Skye, and Glenelg on the mainland—all rocky coasts with fine mountain scenery.

Kincardineshire. Maps 33a and 33b. Area 245,346 acres.

Schists and granite occupy the land in this county along the borders of the Dee Valley and on the coast north of Stonehaven, the granite rising to 2555 feet at Mount Battock.

From Stonehaven southwards to South Water Bridge, and for some distance inland, Old Red sandstone and its accompanying andesite extend over the country: the former constituting a comparatively low-lying tract under cultivation, while the volcanic rocks rise up into moorlands.

Sea-side resort: Stonehaven (rocks, cliffs).

Kinross-shire. Map 33b. Area 46,485 acres.

In this small county the Old Red sandstone and andesites occupy the high ground to the north-west, forming a portion of the Ochil Hills, and they extend to the borders of Loch Leven.

Lower Carboniferous and volcanic rocks occur on the borders of the Lomond Hills on the east, and form the southern parts of the county.

Kirkcudbrightshire. Map 33b. Area 574,587 acres.

This large county includes a considerable part of the Southern Uplands, with Ordovician strata around Carsphairn, Merrick (2764 feet), and other heights, and a broad belt of Silurian from New Galloway to the rocky shores of Kirkcudbright and Castle Douglas. There are many areas of peat over this region. On the coast between Abbey Head and the mouth of the Nith, Old Red sandstone and Lower Carboniferous rocks are exposed. From Dalbeattie eastwards to Criffell (1866 feet), there is a great mass of granite, fragments from which have been dispersed in southern regions in the Glacial Drift. The rock is extensively quarried. Another mass of granite appears at Cairnsmore of Fleet (2331 feet) to the south-west of New Galloway. Further north the Kells Range above Loch Doon and Loch Macaterick is formed of granite, and a small mass is found at Cairnsmore of Carsphairn.

With Wigtownshire this county forms the old province of Galloway.

Lanarkshire. Map 33b. Area 564,284 acres.

This county contains much of the Glasgow coal-field from Glasgow to Airdrie, Wishaw and Carluke; a region drained by the Clyde.

Lanark itself is on Old Red sandstone, and the Falls of Clyde tumble over these rocks with included masses of igneous rock. To the south the Tinto Hills (2335 feet) are formed of felsite. The Clyde rises among the Silurian rocks south of the Lowther Hills, but these Uplands include northwards the famous mining district of Leadhills in Ordovician strata. Some alluvial gold has been met with in this district.

At Lesmahagow the passage-beds of the Silurian yield *Pterygotus* and other fossils.

Linlithgowshire (or West Lothian). Map 33b. Area 76,806 acres.

In this small county the rocks are mainly Coal-measures and Lower Carboniferous strata, with many volcanic rocks; the older portion extending in hilly tracts from Bathgate and Linlithgow to Dalmeny and Queensferry, by the Forth Bridge.

Oil-shale occurs in the Coal-measures.

Nairnshire. Map 33a. Area 127,905 acres.

Nairn, in part a Highland county, contains in the south along the course of the Findhorn river, schists and masses of granite, while near the coast the rocks are Old Red sandstone. The sea-margin is bordered by sandhills, and the lower grounds are much drift-covered. The town of Nairn is a famous watering-place, sometimes spoken of as the "Brighton of the North": from its neighbourhood the views across the Moray Firth are charming.

Sea-side resort: Nairn (stony beach).

Orkney and Shetland. Map 33a.

The Orkney Islands (area 240,476 acres) are formed almost wholly of Old Red sandstone, with igneous dykes. There are few trees, but oats are cultivated in places.

The Old Man of Hoy is a stack of Old Red sandstone, adjacent to cliffs which rise 1100 feet, while the island of Hoy attains an elevation of 1564 feet.

The Shetland Islands (area 352,876 acres) are formed largely of schists in the central parts of the mainland, and in Yell. Unst and Fetlar are formed of schists, with serpentine and gabbro. Old Red sandstone occurs on the west of the mainland and at Lerwick. There is but little cultivated ground.

Peebles-shire. Map 33b. Area 226,899 acres.

This county extends southwards from the Pentland Hills, which are formed of Silurian, Old Red sandstone, with volcanic rocks and Carboniferous. The great boundary fault on the south brings in the Ordovician rocks of the Moorfoot Hills; and also Silurian strata, which extend from Peebles to Broad Law (2754 feet), and to the head of the Tweed near Hart Fell (2651 feet), an important portion of the Southern Uplands. There are mineral waters at Innerleithen.

Perthshire. Map 33b. Area 1,617,808 acres.

In this Highland county are included large portions of the Grampian Hills, drained by the Tay and its tributaries. The region is one of Dalradian schists: a complex of highly altered igneous and sedimentary rocks, with intrusions of granite, diorite, &c. The Loch Tay limestone is included in this group, as well as some conglomeratic beds. In the Forest of Athole, on the north of Blair Athole, Ben Dearg (3304 feet) is formed of granite; while Schichallion (3547 feet) which stands up to the south of the Tummel, far west of Pitlochry. Ben Lawers (3984 feet) which lies to the south-west towards Killin and north of Loch Tay; Ben More (3843 feet) to the south of the railway between Killin Junction and Tyndrum; Ben Vorlich (3224 feet) to the south of Loch Earn; and Ben Ledi (2875 feet) north-west of Callender, are among the prominent heights formed of schists. Among the same rocks, Loch Katrine and the Trossachs lie west of Callender. To the north of Alyth and Blairgowrie, to the south of Dunkeld, and thence north of Crieff, and from Callender to Aberfoyle, is a tract of faulted ground where the schists on the north are brought against the Old Red sandstone, and bands of andesite on the south.

These newer rocks extend to Doune and Dunblane, on the banks of Allan Water; they form the Ochil Hills south-west, and the Sidlaw Hills north-east of Perth, the latter overlooking the famed Carse of Gowrie, an ancient beach level, which borders the Tay between Perth and Dundee.

Throughout the deep valleys there is much drift, and some of the higher mountains, as Schichallion, exhibit ice-marks near the summit.

Renfrewshire. Map 33b. Area 156,785 acres.

In this industrial county, Lower Carboniferous rocks and volcanic rocks (andesites, &c.) predominate—the former at Gourock and Greenock and around Paisley, the latter at Creuch Hill and thence through the heart of the county to the south-east. On the borders of the Clyde, near Renfrew, the marine clays known as the Clyde Valley beds are dug for brick-making. Coal-measures with ironstones occur on the borders of Glasgow.

Sea-side resorts: Gourock (at the mouth of the Clyde), Wemyss Bay (cliffs), Firth of Clyde.

Ross-shire and Cromarty. Map 33a. Area 2,003,065 acres.

This dual county is essentially a Highland district, although the eastern part, the main portion of Cromarty, is largely agricultural.

On the west from Enard Bay, by Lochs Broom, Ewe, and Maree to Applecross, Plockton and Kyle, the shores and inland tracts are formed mainly of Torridon sandstone; while the eastern coast of Enard Bay, large tracts between Loch Broom and Gairloch, and another tract at Jeantown on the borders of Loch Carron, are formed of gneiss, and there are small tracts of gneiss along the borders of Loch Torridon. The main road from Jeantown to Applecross crosses the Torridon sandstone at a height of 2054 feet at Bealloch, and thence descends to the coast, where there is a faulted tract of Triassic sandstones and marls overlain by Lower Lias limestones with oolitic bands. Traces of the same rocks appear on the northern side of Loch Ewe and extend into Gruinard Bay.

Bordering the mass of Torridon sandstone eastwards are belts of Cambrian rock—Durness limestone and quartzite, at Ullapool, Kinlochewe, and Loch Kishorn; while in the interior is a mass of Highland schists with occasional small areas of granite: a grand country, as may be seen from the Highland railway between Dingwall and Strome Ferry. Ben Wyvis (3429 feet) rises boldly to the north of Strathpeffer, a spa noted for its sulphurous and chalybeate waters, and situated on the Old Red sandstone. The principal "sulphur waters" contain a good deal of the sulphates of lime and magnesium. The raised beaches, with their level grass-covered platforms, are well seen at the entrance to Loch Carron.

The eastern part of the region known generally as Cromarty, is formed mainly of Old Red sandstone, with much boulder drift, which extends from Dingwall to Tain and Tarbat Ness, and over great part of the Black Isle, a famous agricultural region.

The Old Red sandstone is bordered on the west by schists, and these old rocks rise up at the mouth of Cromarty Firth to form the Sutors of Cromarty.

The Old Red sandstone of Eathie, south of Cromarty, is famed as the scene of the early labours of Hugh Miller, who there worked as a quarryman. He first called attention to the pavements of fossiliferous Jurassic shale on the foreshore—termed by him "Lias," but now known to be of Kimeridgian age. Northwards, beyond the northern Sutor, beneath the grand cliffs of Shandwick, Lower Oolites, with a thin coal-bed occur.

Lewis, a part of the Long Island of the Outer Hebrides, is attached to Ross-shire. It consists almost wholly of gneiss, with Torridon sandstone at Stornaway, and a small granite tract on the north-west coast. It is a bare and rocky region, with many lakes, and everywhere exhibits evidences of glacial action.

Sea-side resorts: Gairloch, Strome Ferry and Ullapool on the western Ross-shire coast, and Fortrese on the Black Isle.

Roxburghshire. Map 33b. Area 425,657 acres.

Silurian rocks appear in the northern part of this county above Melrose, and from Melrose southwards along the upper part of Teviotdale at Hawick. Eastwards around Jedburgh the county is largely formed of the Old Red sandstone and volcanic rocks (andesites), while southwards in Liddesdale there are Silurian and Lower Carboniferous rocks. These rocks extend to the Cheviot Hills along the English borders. Glacial drift is found over much of the area.

Selkirkshire. Map 33b. Area 164,545 acres.

This is essentially a county of Silurian rocks and drift, extending from Galashiels on the north through the valleys of Ettrick and Yarrow to Ettrick Pen (2269 feet) on the borders of Dumfries-shire. It forms part of the Southern Uplands, a pastoral region, with many sheep-farms.

Stirlingshire. Map 33b. Area 286,338 acres.

This county extends into the heart of the Grampians along the eastern shores of Loch Lomond, with Ben Lomond (3192 feet), where it is a region of schists, but this is bounded on the south, near the lower end of Loch Lomond, by Old Red sandstone which extends from Drymen to Kippen. The lowland tracts comprising Lower Carboniferous rocks occur to the south-east, with volcanic rocks (andesites) in the Campsie Fells, a basalt crag at Stirling Castle, and other masses of basalt to the south. At Falkirk there are Coal-measures, while alluvial tracts border the Forth to Grangemouth.

Sutherlandshire. Map 33a. Area 1,297,846 acres.

In this grand Highland county there is a considerable variety of geological formations. In the wild north-west, from Cape Wrath to Loch Inver, the ground is largely gneiss (Lewisian) traversed by many ancient dykes of igneous rock, that of Scourie exhibiting, as Dr. J. J. H. Teall has shown, the metamorphosis of dolerite into hornblende-schist. Torridon sandstone occurs here and there near Cape Wrath, at The Point of Stoer, Quinag, Canisp, and Suilven, and it rests on an irregular surface of the old gneiss.

This mountain region is a complication of disturbance with much overthrusting; the more prominent heights are Ben More (3273 feet), Canisp (2786 feet), and Suilven (2399 feet).

A broken belt of Cambrian rocks stretches from the Kyle of Durness and Loch Eriboll to the region of Loch Assynt and Inch-na-damph. These comprise the Durness limestone, with *Orthoceras*, *Maclurea*, &c.; underlying quartzites with fucoid beds and shales yielding *Olenellus*, and a lower quartzite, the Eriboll quartzite including the "pipe-rock" with worm-burrows.

The central portion of the county is a mass of schists rising more prominently at Ben Hope (3040 feet) and Ben Clibreck (3164 feet); these rocks extend along the northern coast from Loch Eriboll and the Kyle of Tongue to Strathy Point, and approach the eastern coast at Lothbeg near Brora and Helmsdale.

Granite masses appear at Ben Laoghal (2504 feet), and along Strath Halladale at Kinbrace, Helmsdale, Rogart, Lairg, and near Bonar Bridge.

At Kildonan above Helmsdale, gold has been found in alluvial deposits.

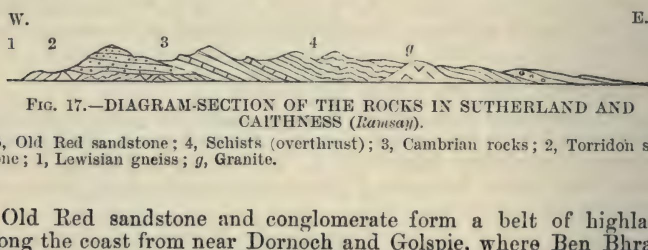


FIG. 17.—DIAGRAM-SECTION OF THE ROCKS IN SUTHERLAND AND CAITHNESS (*Ramsay*).

5, Old Red sandstone; 4, Schists (overthrust); 3, Cambrian rocks; 2, Torridon sandstone; 1, Lewisian gneiss; *g*, Granite.

Old Red sandstone and conglomerate form a belt of highlands along the coast from near Dornoch and Golspie, where Ben Bhragie (1256 feet) and Ben Smeoral are prominent.

The picturesque Golspie Burn is cut through these strata, and the New Red rocks. The latter comprising marls and siliceous and calcareous cornstones appear in the lower part of Golspie Burn and on the shore near Golspie. Northwards near Dunrobin Castle there are reefs of Lower Lias with *Hippopodium ponderosum* and other fossils.

Thence at intervals we find south of Brora the Great Oolite series, with the Brora coal, which is mined near Brora village. Above are the Oxfordian shales, which are worked for brick-making. At a higher horizon, at Clyne Hill to the north, are hard sandstones largely used for building purposes. These are Lower Corallian, and they yield *Ammonites perarmatus* and many remains of cycads.

Further north rough reefs of sandstone, and great boulder beds and breccias intercalated with shales occur. These are mostly of Kimeridgian age, but they yield corals near Helmsdale of Portlandian character, and near Culgower many plant-remains.

The belt of Jurassic rocks inland is mostly concealed by Drift deposits and blown sands.

Blown sands occur at Dornoch and again at Durness.

Sea-side resorts: Brora (sands, cliffs); Golspie (stony beach).

Wigtownshire. Map 33b. Area 310,742 acres.

In this county of promontories, the rocks are almost wholly Ordovician and Silurian. The northern part of the Rhinns from Corsewell Point to below Port Patrick, and the moors north of Glen Luce, are Ordovician. From Balgreggan to the Mull of Galloway, and from Newton Stewart and Glenluce to Wigtown and Burrow Head, the country is formed of Silurian rocks. Over these areas there is much peat, as well as glacial drift: and in the low lands, below Newton Stewart, the Cree traverses a broad tract of valley gravel and raised beach ere it enters Wigtown Bay. A small tract of granite appears to the north of the Mull of Galloway on the western part of that rocky coast; and a belt of New Red sandstone ("Permian") and Lower Carboniferous rocks appears on the western shores of Loch Ryan at Stranraer and northwards. Blown sand occupies the head of Luce Bay.

Sea-side resorts: Isle of Whithorn (cliffs), Port Patrick (cliffs), Stranraer (head of Loch Ryan), Wigtown (head of Wigtown Bay).

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FEATURES OBSERVABLE ALONG THE PRINCIPAL LINES OF RAILWAY IN GREAT BRITAIN.

Our lines of railway have largely aided the progress of Geology not only by opening up a ready means of communication with all parts of the country, but by furnishing many instructive sections of the strata. While, however, it would occupy too much space to attempt an account of all the cuttings, it may be interesting to point out some of the leading geological features observable on the main lines of railway. With the aid of the geological maps, the traveller may thus be led to notice how the character of the scenery and even the buildings erected upon the land have been influenced by the changeful geological structure. It must, however, be borne in mind that in the country north of the Thames there is much glacial drift which is not represented on the accompanying maps.

I. LONDON, TILBURY, AND SOUTHEND RAILWAY.

Starting from Fenchurch Street, we pass for the greater
Map **13** part of our journey over Levels and Marshes of the Thames Alluvium and over terraces of river gravel and brickearth that represent a part of the Pleistocene period, when the land hereabouts probably stood at a lower level. Remains of the mammoth, rhinoceros, hippopotamus, hyæna, and other animals, and also numerous shells including two species now extinct in Britain (*Corbicula fluminalis and Unio littoralis*) are met with in these deposits.

We cross the river Lea between Bow and Plaistow, and the Roding at **Barking**. We pass over the Chalk at **Purfleet**, and near the railway-station the line cuts through an old Chalk-pit, which exhibits in places a capping of the Thanet Beds. Further on, **Grays Thurrock** is noted for its Pleistocene brickearth, as well as for its large Chalk-pits where whiting is manufactured. A little to the north-east, at Hangman's Wood, there have been discovered numerous chambers in the Chalk communicating with the surface by vertical shafts. These openings are known as Deneholes, and it is considered probable that they were made in early times to afford places of security and refuge.

From Stanford-le-hope to Southend we travel, now on the London clay, now on the Alluvium; and not far from the former station we can see Langdon Hill, an outlier of Bagshot Sands and pebble-gravel, from the summit of which may be obtained (in fine weather) a most charming view of the Thames and of the country on either side of it.

Southend itself is built on the gravel and brickearth belonging to the older Thames Valley deposits, and these rest on the London clay. The extensive foreshore is really a "plain of marine denudation," formed of the London clay, with a thin covering of recent silt and mud.

II. GREAT EASTERN RAILWAY.

London by Ipswich to Norwich.

MAP 13 Travelling from Bishopsgate by way of Colchester we cross the Lea River between Coborn Road and Stratford, and over some of the older Thames Valley deposits, which near Ilford are famous for remains of Pleistocene mammalia.

Beyond Romford we journey across the bare London clay, capped in the deep and long cutting at **Brentwood**, by the Lower Bagshot beds and here and there by traces of boulder-clay. These Lower Bagshot beds consist mainly of sands and pebble-gravel, the sands passing down by alternations with loam and clay (worked for brick-making) into the London clay below. They form the higher and more picturesque tracts of Essex, with many fir-trees in places, as at Brentwood and Warley, Billericay, and Stock.

Leaving Brentwood we continue on the London clay, capped here and there with drift gravel and boulder-clay, through a deep cutting near Widford, on to Chelmsford. Here the valley deposits of the Chelmer have yielded remains of mammoth, and the brickearth has been largely worked. Onwards again to **Colchester** the country is for the most part formed of London clay covered in many places by boulder-clay and gravel. At Copford, south-east of Marks Tey, deposits of Pleistocene brickearth have yielded land and freshwater mollusca and remains of mammoth and hippopotamus.

MAP 27 Near **Manningtree** we cross the estuary of the Stour, and afterwards traverse a tract of London clay capped by Red Crag, and glacial sand and gravel. We pass through a tunnel in the London clay before reaching **Ipswich**, and the estuary of the Orwell. The town lies partly on Reading beds, London clay, glacial gravel, and valley gravel.

At Bramford we come upon the Chalk, which here forms the northern margin of the London Basin, and thence to **Haughley** junction we traverse the same formation, much concealed by drift.

MAP 21 Around Mellis and in the neighbourhood of Tivetshall the ground is composed chiefly of the chalky boulder-clay, and the cuttings at Florden are excavated in it. Some of the houses in this area are built of clay-lumps or sun-dried masses of "brick" formed of this boulder-clay; but the buildings are usually faced with brick. The soil is a favourable one for wheat and beans.

South of Florden, there is a large ballast-pit in the glacial "Cannon-shot gravel." Before reaching **Norwich** the railway cuts through a prominent wooded hill, formed for the most part of glacial sand and gravel; then crossing the valley of the Yare, it passes through cuttings of glacial sand and brickearth, and leads us to the Victoria Station.

Ipswich to Lowestoft and Yarmouth.

MAP 27 From Ipswich we cross a plateau of boulder-clay to Bealings and Woodbridge, where the Deben Valley is cut through glacial drift to Red Crag and London clay.

We leave this valley and cross boulder-clay and glacial sands at Campsey Ash, thence traversing the valleys of the Alde and its tributaries, over Crag with bordering hills of glacial drift to **Saxmundham.** The region is picturesque with its mixture of heath and arable land. From Saxmundham to Halesworth and Beccles we pass over a great tract of rich corn land mainly of chalky boulder-clay; but the scenery is diversified by the Minsmere Valley at Darsham, to the east of which is Westleton with its flint pebble-beds. We cross also the Blythe Valley at Halesworth, where again the Westleton pebble-beds and underlying Crag are exposed. North of **Halesworth** Station the cutting at one time showed a fine section of the boulder-clay. As we leave Beccles for **Lowestoft** we pass along the borders of the Waveney Valley, by Oulton Broad, and over tracts of glacial gravel.

MAP 21 The route to Yarmouth continues direct from **Beccles** across the alluvial meadows of the Waveney, and thence over tracts of glacial drift, with underlying Norwich Crag which has been exposed near Aldeby. We again cross the Waveney, and, passing near Fritton Decoy, over heathy grounds of glacial sands and gravels and boulder-clay, soon arrive at **Great Yarmouth** (see p. 106).

London by Cambridge to Norwich, Yarmouth, and Cromer.

MAPS 2, 13 Proceeding from London by Cambridge we travel for some distance along the valley of the Lea, filled with alluvial deposits that near Walthamstow have yielded remains of beaver, reindeer, elk, wolf and other animals. On the west a long fringe of valley-gravel borders the river, and owing to its having offered suitable ground and means of water-supply from springs or shallow wells for the early settlers, a number of villages and towns are found along it.

Eastwards the London clay makes the surface soil, and rising gradually it forms the higher grounds of Epping, surmounted at Highbeech by Bagshot sand. Much of Epping Forest is based on London clay, the soil of which is well suited for the oak and the hornbeam.

Leaving **Broxbourne** we enter the Stort Valley, bordered at first by Reading beds and London clay, and higher up by glacial sands and gravels, the adjacent plateaus being formed of chalky boulder-clay.

At **Bishop's Stortford** we again reach the Reading beds, and shortly afterwards the Chalk, which is much concealed by drift. Beyond Elsenham we enter the Cam Valley, with here and there cuttings and tunnels in the Chalk from Newport, onwards to **Great Chesterford.** Along this tract there is a deep channel of glacial drift, no less than 340 feet thick at Newport, as described by Mr. Whitaker. At Littlebury, to the west of Saffron Walden, we pass from the Upper to the Lower Chalk, and here the bordering hills being freer from drift assume a Down-like character.

MAP 4 Thence we pass over the Lower Chalk by Shelford to Cambridge, with the Gog Magog Hills capped by Middle Chalk to the east.

At **Cambridge** we find brickyards in the Gault, and there were at one time coprolite-diggings at the base of the Chalk. Thence to Ely the railway runs for the most part over alluvial flats. Eastwards a low hill formed of the Corallian beds rises out of the marshes at Upware. Just beyond **Ely,** whose grand Cathedral stands on Lower Greensand, we may detect the celebrated excavation known as Roswell or Roslyn Hole, where a fine section of Kimeridge clay is to be seen, and where boulder-clay and a large transported mass of Chalk have also been exposed.

The old Isle of Ely is a wide-spreading tract of rising ground formed of Kimeridge clay, with outlying masses of Lower Greensand, and surrounded by the alluvial flats of the Fenland. From Ely to Brandon the line crosses a wide expanse of this alluvium. Then at

MAPS 27, 21 Lakenheath as we approach **Brandon** we reach the Chalk again. Between this town and **Thetford** the valley of the Little Ouse or Brandon River contains valley-gravels and brickearth, which have yielded many palæolithic implements. The old neolithic pits of Grimes Graves lie north-east of Brandon. The higher grounds are covered here and there by boulder-clay, and drift gravel and sand. The sand predominates, and has at times swept over the country in sand-storms or sand-floods, as at Santon Downham, east of Brandon.

At **Roudham** Junction we are in the midst of an extensive tract of heath-land and warren, which early in this century was the haunt of the Bustard. Many picturesque and natural pools, called Meres, occur in this neighbourhood and northwards towards Wretham. They are most of them based on the Chalk, and serve to indicate the plane of saturation.

Passing towards **East Harling** and **Attleborough** we come on to the boulder-clay, and the scene changes to a highly cultivated district. At **Wymondham** there are deep cuttings in the glacial gravel and boulder-clay, and we continue mainly on boulder-clay until we reach the Yare Valley, where the Chalk and overlying Crag series are exposed, with valley-gravels at Trowse and Thorpe Station, **Norwich.**

From **Norwich** to Yarmouth we follow for some distance the Valley of the Yare, whose bordering hills consist of Chalk, supporting the Norwich Crag, and various drift deposits.

Many old Chalk-pits in Thorpe village have been utilized in the rear of the houses and turned into picturesque gardens. Further on we cross a small low-lying mass of boulder-clay near Postwick Grove, a locality famed for its shelly crag.

At **Brundall** the Norwich Crag was opened up in the railway-cutting close to the Station. Thence to **Acle** the cuttings are mostly in glacial drift, and from Acle to Yarmouth we cross the alluvial marshes, and have a peep at the estuarine broad of Breydon.

Yarmouth is built on blown sand and recent marine shingle: but below these the London clay and Reading beds have been proved to overlie the Chalk in a deep well made for Lacon's Brewery.

From **Norwich** to Cromer we pass, just beyond **Whitlingham** Station, the noted Crag-pit of Thorpe, where the Crag is seen reposing on the Chalk. The shelly-beds occur at the base, and there also remains of mastodon and other mammalia may be found: higher up there is pebbly gravel, with layers of iron-sandstone containing casts of shells. Thence to Cromer we traverse a comparatively flat agricultural tract formed of glacial sand and brickearth, but intersected at **Wroxham** by the Valley of the Bure, on the borders of which the pebbly gravels of the Crag series are exposed, while along the valley are many picturesque broads.

The cliffs at **Cromer** are formed of glacial clay, sand, and gravel, often much contorted; and these beds rest on laminated clays, shelly sands, gravels with peaty beds and occasional tree-stumps, known as the Forest-bed series, which has yielded many mammalian remains.

Ely to Hunstanton.

MAP 4 From **Ely** to Lynn the railway traverses the eastern margin of the Fenland, through which the Ouse takes its course; we proceed by Littleport, situated on an island of Kimeridge clay capped by boulder-clay and gravel, to Denver and **Downham Market** which are also on Kimeridge clay, with higher MAP 21 grounds to the east formed of Lower Greensand, and intersected further north by the Nar Valley.

At **Lynn** we again border the picturesque Lower Greensand hills which extend to **Sandringham** and Snettisham, and we traverse several cuttings in the sands. Westwards we overlook the waters of the Wash.

The building-stone of this neighbourhood, largely quarried near Snettisham, is a brown ferruginous sandstone (Carstone), popularly called "Gingerbreadstone." It is easily worked, and is chopped into shape with an axe, but hardens on exposure. Most of the houses of the neighbourhood bear witness to its use.

At **Hunstanton** the chief geological attraction is the cliff (about a mile in length) formed of White Chalk, below which is a band of Red Chalk, and these are based on the brown Carstone of the Lower Greensand, which forms a pavement on the foreshore.

III. GREAT NORTHERN RAILWAY.

London to Aberdeen.

MAP 2 Leaving King's Cross we traverse two tunnels excavated in the London clay, the second passing beneath the old Copenhagen Fields. Onwards past Finsbury Park we continue on the same formation with here and there cuttings and tunnels as far as

Hatfield, traversing an undulating and well-timbered grass-country, the bordering hills, as near Muswell Hill, Southgate, **Barnet** and Potter's Bar, being capped by boulder-clay and drift gravel. As we approach **Hatfield** we cross the outcrop of the Reading beds, and thence proceed over a broad tract of Upper Chalk—with drift gravel and sand and occasional Eocene outliers. Much of the land is arable, but it is well wooded and pleasantly diversified. We cross the Lea Valley, north of Hatfield, and beyond Welwyn pass through tunnels and cuttings in the Chalk. The country becomes more undulating, while the fields are larger and the hedgerows thinner as we get into the more open Chalk country. The cuttings show here and there irregular cappings of clay-with-flints; an occasional Chalk-pit is seen, while superficial deposits are indicated by gravel-pits and brickyards, as we pass Knebworth and Stevenage, and reach **Hitchin** Station, where there is a fine Chalk-pit with overlying drift gravel. Hereabouts we cross the escarpment of the Middle Chalk, which forms more prominent downs towards Luton on the south-west, and Royston on the north-east.

Entering a low-lying agricultural, and in places, fenny tract, we pass at the Three Counties Station the Arlesey Lime and Portland Cement Works, where the Chalk marl is worked, and further on the Arlesey Brickfields, where the Gault is dug.

We then traverse the fir-clad range of the Lower Greensand between **Biggleswade** and **Sandy**, and in this formation phosphatic nodules were at one time worked at Potton. Hereabouts it consists mainly of brown and white false-bedded sands.

We now enter the vale of Oxford clay, a well-timbered country of arable and pasture land. The clay may be seen in a brickyard near Sandy, and it extends along our course by the eastern side of

MAP 4 the Ouse, through St. Neots and Huntingdon to **Peterborough**, covered in places by valley-gravel and by much boulder-clay, and near Holme by the alluvial deposits of the Fenland. Fletton, near Peterborough, is noted for its extensive brickyards in the Oxford clay.

MAPS 22, 20 North of Peterborough Station, the Cornbrash is exposed for some distance and thence we proceed across the Lower Oolites as far as Grantham. From a flat country with rich looking pastures we pass to one with bolder features, with a red-brown soil and much arable land, and with stone-built houses and stone fences dividing the fields. Cuttings mainly in the Great Oolite series, comprising limestones and Estuarine clays, are passed through as far as Essendine and towards Little Bytham, where we also traverse cuttings in the false-bedded and massive freestones of the Inferior Oolite (Lincolnshire limestone). Onwards past Corby to Great Ponton, we again traverse Great Oolite and a deep cutting in boulder-clay, and then reach the great cuttings and tunnel in the Lincolnshire limestone of Great and Little Ponton.

As we approach **Grantham** we leave the wooded escarpment of the Lincolnshire limestone and enter a great vale of Lias, a clay-country of meadow and pasture with some arable land, and where red bricks replace the stone in the buildings. The blue clays of the Upper

Lias are exposed near Grantham; and in this neighbourhood iron-ore is worked in the Middle Lias.

MAP 24 The lower beds yield Blue Lias limestones and form a low escarpment, which we traverse before reaching **Newark-on-Trent,** and entering upon the New Red marl. Newark is noted for its alabaster and plaster works, the gypsum being obtained from the Red marls.

Onwards past Tuxford to **Retford** we cross flat tracts and undulating arable lands, and through cuttings in red marl with occasional beds of sandstone and gypsum. At Retford the Lower Keuper sandstones rest on the Bunter sandstone and pebble beds. Thence over the Bunter formation, with drift sands and gravels by Bawtry, we traverse a low-lying tract of arable ground, pasture and woodland.

MAP 30 The red sandstone of the Bunter is exposed near **Doncaster,** beyond which, through Selby and York to Northallerton, we proceed through the drift-covered area of the vale of York. Similar ground is traversed on the railway by Goole to **Hull.** In this flat or slightly undulating agricultural country there are curious moraine-like ridges of drift, as at Escrick, north of Selby, and these practically conceal the underlying New Red rocks.

North Eastern Railway.

At **York** there are extensive deposits of sand, gravel and laminated clay ("warp"), the clays being worked for bricks and tiles. Thence towards Thirsk we pass on to the New Red marl, bordered eastwards by Rhætic beds and Lias, much concealed by drift.

From Northallerton we continue for a space on the Red marl, with the Lias escarpment and the high Oolitic range of the Hambleton and Cleveland Hills to the east, and then pass on to the drift-covered New Red sandstone of the Tees Valley, by Croft, noted for its sulphur-spa.

MAP 12 A little further on is **Darlington** with its iron-works, situated on the Magnesian limestone (Permian); and we continue on this formation over a country more diversified. There are deep cuttings, for the most part grass-covered, but we pass quarries and limeworks at Aycliffe, and quarries and fine cuttings in the irregular beds of Magnesian limestone at **Ferry Hill**—a locality noted for its fossil fishes.

At Ferry Hill we leave the escarpment of Magnesian limestone, and pass on to the Coal-measures. Thence through **Durham** to Newcastle we traverse an undulating, grassy and agricultural country, with somewhat stunted trees in the hedgerows. Iron-works and coal-works are passed here and there, and cuttings in hard sandstone, while many picturesque wooded ravines and dells are crossed.

MAP 23 From **Newcastle** onwards to Berwick-on-Tweed the country is fairly flat, but it is pleasantly diversified by deeply cut wooded dells. Through Morpeth and as far as Chevington, we travel over Coal-measures, while beyond we cross the Millstone grit at Warkworth on to the Lower Carboniferous rocks which also are coal-bearing. Near Warkworth we have a first view of the sea across Alnmouth Bay, with Coquet Island to the south-east.

Beyond Longhoughton we cross the Great Whin Sill, which extends to Dunstanburgh Castle on the coast. Further north at Belford we again traverse the Sill, which is met with also at Bamburgh and in the Farne (or Fern) Islands. We now pass near to the coast, with Holy Island (Lower Carboniferous) standing out a few miles distant from the broad expanse of sands. Thence by Scremerston, with its coal-works, large quarries and lime-kilns, we reach Tweedmouth and Berwick-upon-Tweed.

North British Railway.

MAP **33b** From **Berwick** to Burnmouth we continue at a high level above cliffs in the Lower Carboniferous rocks, here mostly red sandstone, with Silurian slaty rocks on the west. We now pass inland on to the Old Red sandstone at Ayton and Reston Junction, and over portions of the Lammermuir Hills, formed of Silurian rocks, by Grant's House. From Cockburnspath to **Dunbar** we traverse the Lower Carboniferous rocks, and hereabouts we may have glimpses of the Bass Rock. From East Linton we traverse a region of eruptive rocks which extend to Drem Junction, and include North Berwick Law, a volcanic vent which rises to the north. Thence we pass over Lower Carboniferous rocks to **Edinburgh**, with a tract of Coal-measures (the Midlothian coal-field) at Musselburgh. The noble heights of Arthur's Seat and other crags in the vicinity of the city are formed of igneous rocks of Lower Carboniferous age.

From Edinburgh to the Forth Bridge, and onwards for some distance past Dunfermline, we continue on Lower Carboniferous strata with many eruptive rocks. On the borders of Loch Leven and at Kinross we are on the Old Red sandstone, while eastwards rise the volcanic rocks of the Lomond Hills; and we proceed on the Old Red sandstone to Cupar, crossing a volcanic area before reaching the Tay Bridge.

MAP **33a** From **Dundee** to Stonehaven we again traverse Old Red sandstone, with sand-hills between Broughty Ferry and Carnoustie, and volcanic rocks near **Montrose**. Beyond **Stonehaven** we come into the region of Highland schists, and finally reach **Aberdeen** with its huge quarries of grey granite.

IV. MIDLAND RAILWAY.

London to Glasgow and Manchester.

MAP 2 Starting from St. Pancras, we travel through tunnels and cuttings of the London clay past Haverstock Hill and South Hampstead, onwards by the Brent Reservoir to **Hendon**. Thence we pass through an undulating grass-country with well-timbered hedgerows, by Mill Hill which has small cappings of pebble-gravel, until we reach Radlett, where the Reading beds appear, with a capping of London clay and drift gravel. In a pit in the adjoining park the Hertfordshire puddingstone (Reading pebble-bed) was at one time exposed. The outcrop of the Reading beds here forms a low scarp overlooking the Chalk country which we now traverse; a region where much of the land is under arable cultivation. The Chalk here and for some distance onwards to **St. Albans** and Harpenden is much concealed by drift gravel, sand, loam and clay-with-flints, accumulations which fill irregular cavities or "pipes" in the Chalk. Beyond Harpenden we reach a more open country in the Luton Downs and the Dunstable Downs to the south-west, an extension of the Chiltern Hills, where the middle beds of Chalk form a fine escarpment. There are lime-works in the Chalk marl north of Leagrave, beyond which at Harlington we cross the flat clay-country of the Gault. From near Flitwick to **Ampthill** we traverse the elevated sandy range of the Lower Greensand, which extends to Woburn on the west; a healthy region with fir plantations.

The cutting and tunnel at Ampthill were excavated through grey and blue clays that lie between the Kimeridge and Oxford clays. They represent the Corallian stone-beds of other localities, and are designated the Ampthill clay. On emerging from the tunnel we cross a vale of arable and pasture land formed by the Oxford clay and soon reach **Bedford.** The gravels of the Ouse Valley have yielded remains of hippopotamus, and palæolithic implements, discovered many years ago by James Wyatt.

Both to the south, and at Oakley to the north, of Bedford the Kellaways beds, comprising loams and sands with large doggers of calcareous sandstone, have been exposed. These beds overlie a thin band of Cornbrash which rests on the Great Oolite clays and limestones also worked at Bedford. We traverse these formations with cappings of drift as we advance northwards, repeatedly crossing the Ouse. Near Irchester we come upon the Estuarine series at the base of the Great Oolite, with underlying Northampton sand, while at a lower level the Upper Lias clay is exposed along the borders of the Nen Valley and of the Ise tributary along which we travel past **Wellingborough.** In this neighbourhood the Northampton sand is extensively worked for iron-ore, and onwards to **Kettering** we pass numerous iron furnaces. The bordering hills for some distance are formed of Northampton iron-ore with coverings of Estuarine beds, Great Oolite, and drift, while the deep valleys are excavated in the Upper Lias. After traversing cuttings in the Northampton sands we reach Desborough and thence leave the Oolitic escarpment for the great vale of Lias, a famous hunting country, which extends from **Market Harborough** northwards to Melton Mowbray, and north-eastwards to near Leicester. There is much drift here as elsewhere in the Midlands. At South Wigston, near Glen Parva, a fine section of boulder-clay, Rhætic beds and Red marls has been opened up in a brickyard.

MAP 22

MAP 19

At **Leicester** we pass over the New Red marls which are worked for brick-making and locally yield gypsum, nodular masses of which appear in the cutting near Syston. Further on, at Barrow-on-Soar, the Lower Lias limestones are largely worked

MAP 24

for hydraulic lime and cement, and many fossil saurians, fishes, mollusca, and crustacea have been obtained.

At Mount Sorrel there are large granite quarries, the stone being extensively used for road-metal and for paving, while the waste material is utilized with Barrow cement in the manufacture of artificial pavements, &c. Further west lie the ancient slaty and igneous rocks of Charnwood Forest.

Passing **Loughborough** through the Quorn hunting country, we proceed over the Red marls near Hathern with its terra-cotta brick-works, and across the broad alluvial tract of the Trent Valley to **Trent** and Long Eaton.

MAP **9** We now traverse a belt of Bunter and Keuper sandstones to Stapleford and thence passing Stanton Gate with its iron-works and prominent mound of slag, we enter the Nottingham and Derbyshire coal-field, the southern portion of the great Yorkshire coal-field. We pass through many cuttings in the hard sandstones, grits, and shales of the Coal-measures, as between Codnor Park and Alfreton, and from Doe Hill to Clay Cross, where the beds in places are sharply folded. Here and onwards past **Chesterfield** there is abundant evidence of coal-mining activity.

Whether we proceed by Dronfield and **Sheffield**, or by Staveley, Woodhouse Mill, and Rotherham to Swinton, we see many sections, collieries and iron-works, while agricultural tracts and wooded hills here and there diversify this region of mines and factories. MAP **30**

Beyond Treeton we may note red false-bedded sandstone—stained Coal-measure sandstone known as the Rotherham red rock. Leaving **Swinton** we pass Darfield, noted for its main coal, and by a millstone manufactory to Cudworth, whence through Normanton to Leeds we traverse occasional sections of Coal-measure sandstone, with here and there seams of coal.

After passing **Leeds**, as we proceed up Airedale we enter a region of bolder features. The Millstone grit appears along the base of the valley above Kirkstall, and we pass large stone quarries at Calverley Bridge, and fine rock-sections at Shipley. We reach the open moorlands of the Millstone grit at Bingley, where the rock is quarried, and thence by Keighley as far as Canonley we continue on the same formation, passing on to the Carboniferous limestone series at **Skipton.** Thence we traverse a country mainly of Yoredale rocks and Carboniferous limestone, with occasional sections of boulder-clay, to Settle. Between Hellifield and Long Preston evidence of lynchets may be noted in places. Pendle Hill, a scarp of Millstone grit, lies some distance to the south-west near Clitheroe. MAP **18**

Beyond Long Preston we proceed along the Ribble Valley, across a belt of Millstone grit, to **Settle.** Here the characteristic features of the "Great Scar Limestone" are manifest in the Giggleswick Scars on the west and the Langcliffe Scars on the east.

Between Stainforth and Horton we continue up Ribblesdale across a tract of Silurian rocks. Beyond we see the prominent mountains

of Millstone grit on the Carboniferous limestone series: Penyghent (2270 feet) to the east, and Ingleborough (2373 feet) to the west. In this wild region we traverse cuttings in the Carboniferous limestone series and boulder-clay, and can observe drift mounds here and there as we pass Ribblehead. Whernside, capped by Millstone grit (2414 feet), now stands out boldly to the north-west. Onwards we traverse a long tunnel and a cutting in Yoredale shales, cross the beautiful Dent Valley, and further on to the east of **Hawes**
MAP 8 **Junction** we look down Wensleydale, the valley of the Ure which takes its rise in the Millstone grit fells to the north-east. Other fells rise boldly to the north-west, including the Wild Boar Fell (2323 feet). Throughout the journey from Settle we traverse a grand country of mountain and moor, with rapid stone-strewn water-courses and occasional cascades.

At **Kirkby Stephen** we reach the Permian rocks at the head of the fertile Vale of Eden, a wooded agricultural region. These rocks, comprising red Penrith sandstone, breccia, and shales, occupy the western side of the vale, and extend beyond Armathwaite. Bunter (St. Bees) sandstone borders the eastern side of the vale, and extends from Cotehill as far as Carlisle, where we reach the Keuper marls. For short distances Lower Carboniferous shales and sandstones are exposed in cuttings north of Appleby and south of Cotehill. The red rocks appear here and there in the cuttings, but they are much concealed by drift, fine sections of which were described by
MAP 7 Mr. J. G. Goodchild, notably at Culgaith, Longwathby, and Armathwaite. South of Lazonby a large esker has been cut through. Beyond Longwathby there is a fine view south-westwards across the Eden to the mountains of the Lake District. Eastwards there rise the fells of Dufton, Milburn Forest and Cross Fell.

To the west of **Carlisle** there is a tract of Lower Lias almost everywhere concealed by a thick coating of boulder-drift.

Glasgow and South Western Railway.

Northwards we journey across the drift-covered Red marls and sandstones, and the alluvium and peat of the Esk Valley. Thence we skirt the northern shores of the Solway Firth, over Red
MAP 33b rocks and drift to Annan, and over Carboniferous rocks by Cummertrees and Ruthwell to the Nith Valley at **Dumfries**, where the New Red sandstones are extensively quarried for building-stone. Further on we traverse the Silurian and Ordovician rocks of the Southern Uplands between Auldgirth and New Cumnock, with a tract of Lower Carboniferous and New Red rocks from Closeburn through Thornhill to Carronbridge, and a tract of Coal-measures at Sanquhar and Kirkconnel. Thence we cross the boundary-fault on to the Ayrshire coal-field, passing over a complex series of Carboniferous and volcanic rocks, with Permian at Mauchline, Old Red sandstone south of Hurlford, Coal-measures at **Kilmarnock**, and a great series of Lower Carboniferous strata and volcanic rocks onwards by Barrhead to the Clyde Valley and the Coal-measures of **Glasgow**.

Trent to Manchester.

From **Trent** to Derby we proceed along the alluvial tracts
MAP 9 of the Derwent, bordered by New Red marls, and, continuing along the same valley, we pass a belt of Keuper and Bunter sandstones, beyond which the bordering hills are formed of Lower Carboniferous rocks and Millstone grit. Beyond **Duffield** we traverse the south-western end of the Derbyshire coal-field, through Belper to Ambergate, along a picturesque, well-wooded valley.

From Ambergate we cross the Millstone grit, and near **Matlock** pass through tunnels and cuttings and enter the charming dale country of Derbyshire, formed of Carboniferous limestone and shales. Thence we cross this region of crags and wooded and grassy slopes by Darley Dale, Haddon Hall, Bakewell, Monsal
MAP 5 Dale, and Miller's Dale, near Buxton, to **Chapel-en-le-Frith,** to the north-east of which Kinderscout, capped by Millstone grit (2088 feet), forms the prominent feature in the Peak District. Both near Matlock and Miller's Dale the limestone has interbanded volcanic rocks, locally known as Toadstone, and we note, by the way, many a quarry and lime-kiln. Thence crossing the Millstone grit by Chinley and Bugsworth we pass fine cuttings and quarries in the rocks, and enter a region of dark shales and sandstones belonging to the Cheshire and Lancashire coal-field. Thick drift sands and gravels appear in places, and we cross deep wooded valleys with fine hills, as we pass onwards to Marple and Bredbury. Beyond is a flat or undulating agricultural tract of drift overlying New Red
MAP 18 rocks. At Reddish we notice cuttings of reddish sand, and thence soon reach the city of **Manchester.**

V. LONDON AND NORTH WESTERN RAILWAY.

London to Birmingham, Liverpool, Carlisle, Thurso and Wick, to Kyle of Lochalsh, and to Holyhead.

Leaving Euston Station, we pass through bricked-up
MAP 2 cuttings and the Primrose Hill tunnel, excavated in the London clay, and, passing Willesden Junction, we traverse the same formation as far as Bushey. Being a clay country, with no ready supply of water from surface wells, it has been long a thinly populated tract of meadow and pasture land—an undulating country with many pleasant lanes shaded by trees. Along the line of railway the population is now rapidly increasing as at **Harrow,** with its capping of Bagshot Sands, and at Stanmore to the east, the highest ground in Middlesex (500 feet) formed of pebbly gravel.

At Bushey we cross the Colne Valley, excavated through the Reading beds into the Chalk, and, passing **Watford,** we traverse a picturesque country formed of Chalk with cappings of drift gravel and clay-with-flints. Several cuttings and tunnels are passed through, and we reach the bold Chalk scarp of the Chiltern Hills at **Tring,** noticing the smooth outlines of the downs at Ivinghoe and Totternhoe to the north-east. The cutting to the north is in the softer Chalk marl. The Upper Greensand is feebly represented in this neighbourhood, and we cross over the flat area of Gault clay at Cheddington, part of the fertile Vale of Aylesbury, passing near a Chalk outlier with terraces of cultivation or lynchets, at West End Hill to the south-west.

At **Leighton Buzzard** we reach the Lower Greensand, which yields a variety of sands for economic purposes. Thence, passing through a short tunnel in this formation, we traverse a vale of Oxford clay, with much boulder-clay and drift gravel, through Bletchley, near Fenny Stratford, with the uplands of Woburn Sands (Lower Greensand) to the east.

At **Wolverton**, after crossing the outcrop of Cornbrash, we pass on to the Great Oolite, which is quarried for lime-burning near Stony Stratford and Newport Pagnell. In this region the Inferior Oolite series (Northampton Sands, &c.) is but feebly represented or absent, and the Upper Lias clay appears in parts of the Ouse Valley near by.

MAP **22** Northwards from Castlethorpe to Roade, we pass through cuttings in the Great Oolite series, with bands of limestone and clay; and at **Blisworth** we come upon the underlying ironstone of the Northampton Sands, which rests on the blue clays of the Upper Lias. Iron-furnaces may be noticed here and onwards towards **Northampton.** Leaving Blisworth, we enter the vale of Lias, passing through clay-cuttings near Weedon, and further on through the great Kilsby tunnel, excavated in Lower Lias

MAP **29** clays. Onwards to **Rugby** we traverse an undulating grass country, with many a ridge and furrow, and as we approach the town we pass deep cuttings in glacial sands. The old main line to Birmingham passes over the Lower Lias, which is extensively quarried west of Rugby, and over a low-lying tract of Red marl, with drift gravel. We cross the Avon near Brandon and Wolston, and further on traverse the New Red sandstone which, together with red marls, is excavated in cuttings and tunnels near **Coventry.** Thence we pass over further tracts of Red sandstones and marls,

MAP **26** much drift-covered, ere we reach **Birmingham.** Between Birmingham and Wolverhampton lies the Black Country of the South Staffordshire coal-field, with its coal-mines and tips of waste shale and sandstone, its iron-furnaces and heaps of slag.

Rugby by Carlisle to Thurso.

MAP **29** Journeying north-westwards from **Rugby** we pass near to quarries in the Blue (Lower) Lias, and then cross a drift-covered area of New Red (Keuper) marls and sandstones before we reach **Nuneaton,** where the Red sandstone is quarried. Between Nuneaton and Atherstone we skirt on its north-western side a region of old rocks, with the Caldecote volcanic series (Pre-Cambrian), the Hartshill quartzite (Cambrian), largely quarried for road-metal, and the overlying Stockingford shales (also Cambrian). The railway continues on the New Red marls and sandstones to

Polesworth, whence to **Tamworth,** it crosses the northern
MAP 26 end of the Warwickshire coal-field, and again passes over the New Red rocks near **Lichfield** and onwards to Armitage and Rugeley. Here we are on the borders of Cannock Chase, the northern end of which, a tract of picturesque moorland hills, is formed of the Bunter pebble-beds, and extends onwards by Colwich, to near **Stafford.** Thence to Crewe, we pass over Keuper marls, with sandstones near Standon Bridge, and with Bunter beds, and a part of the North Staffordshire coal-field at Madeley. Near **Crewe** the Keuper marls yield rock salt and brine springs. This
MAP 5 country is on the whole flat and uninteresting, and it is much drift-covered. We continue on the Keuper marls to the borders of the Mersey Valley, where Keuper and Bunter sandstones re-appear.

Further on at Hartford the ground is more undulating, at Acton Bridge we cross the River Weaver, and wooded hills diversify the scene ere we reach the flats bordering the Mersey.

From Acton Bridge to Liverpool the line continues on Keuper marls and drifts to near the borders of the Mersey, where we pass on to Keuper and Bunter sandstones. We cross the river
MAP 18 at Runcorn, and continue on Bunter sandstone, through Allerton to **Liverpool** which is situated partly on Bunter, and partly on Keuper sandstone.

MAPS 5, 18 From Acton Bridge to Wigan we continue on Bunter beds through **Warrington,** passing cuttings in sandstone, and soon enter upon the South Lancashire coal-field. Coal-mines and brickyards now appear, as we proceed through **Wigan,** over a flat and otherwise uninteresting country. At Boar's Head and Euxton the monotony is broken by wooded ravines. Further north, by Leyland, we cross tracts of Keuper and Bunter with much drift sand, and then pass over the Ribble on a viaduct of fifty-six arches, and reach **Preston.** Onwards to Garstang we traverse a hilly country with cuttings in the Bunter sandstone and pebble-beds, while to the east appear the bold hills of the Lancashire Moors (Longridge Fell, Bleasdale Moors, &c.). From **Garstang** onwards to **Lancaster** we enter upon an area of Millstone grit rising into fine moorlands on the east, with drift here and there. Thence we cross the Lune, and the country becomes more hilly and picturesque. On the west of Hest Bank Station we see the broad sands of Morecambe Bay, and at Bolton-le-Grange notice huge boulders in the drift.

West of **Carnforth** crags of Carboniferous limestone appear.
MAP 8 and onwards, by Burton, Holme, to near Oxenholme (for Kendal) we traverse a district of this rocky formation. Thence we enter upon the Silurian strata, and its grand scenery commands attention along our route by Grayrigg, Low Gill and **Tebay** Junctions.

Beyond this we pass through traces of Old Red sandstone
MAP 7 or Carboniferous conglomerate, and more Carboniferous limestone between Shap and Penrith, having on our west the rough hill of Shap granite and the mountains of the Lake District.

At **Penrith** we enter upon the Permian rocks of the Vale of Eden, which, near **Carlisle**, are capped by Keuper marls and Lias, everywhere greatly concealed by drift. The bold outline of the Pennine Chain rises to the east.

Caledonian Railway.

In the cliffs at Stanwix, on the River Eden, the red and green Keuper marls with bands of limestone are exposed, and thence we traverse a drift-covered country with some alluvial pastures and many tracts of peat, past Rockcliffe and Floriston, until we cross the Solway and enter Scottish land near the once famous Gretna Green.

MAP **33b** We now pass over a tract of New Red sandstone, much drift-covered, on to the Lower Carboniferous rocks at Ecclefechan, and thence over a belt of Old Red sandstone and volcanic rocks to the Silurian rocks at Lockerbie. From this point we traverse the bold and mountainous region of the Southern Uplands, formed largely of the Silurian rocks, tilted and folded and traversed here and there by igneous rocks. In the lower grounds of Annandale there are beds of New Red strata, concealed, however, by thick drifts. Beyond Lockerbie we pass Jardine Hall, to the west of which were the quarries of Corncockle Muir, which yielded Labyrinthodont footprints. (See p. 92.)

At Beattock we are in the heart of the Upland region. **Moffat** lies to the north-east, and beyond are the heights of Ettrick and Hart Fell (2651 feet), while to the south-west is Queensberry (2285 feet).

At Elvanfoot, in Clydesdale, we cross on to Ordovician rocks, and not far to the west is the metalliferous Leadhills region, with the Lowther Hills to the south.

At Lamington we cross the southern boundary-fault of the Clyde and Forth Basins, on to the Old Red sandstone and Carboniferous rocks, with many contemporaneous and intrusive igneous rocks, with also coverings of boulder clay and mounds of gravel. We pass for the most part over the older of these rocks by **Carstairs** to Carluke, whence we traverse the Coal-measures by **Motherwell** and Coatbridge. We skirt the borders of the coal-field by Larbert, and continue on Lower Carboniferous rocks to **Stirling**, with its fine castle perched on a crag of basalt.

Crossing the Forth, with its alluvial deposits, we proceed

MAP **33a** along the banks of Allan Water over a tract of Old Red sandstone, with the volcanic rocks of the Ochil Hills rising boldly to the east of **Dunblane**. We pass to the north-west of the range by Crieff Junction to Perth, to the north-east of which the volcanic range is continued in the Sidlaw Hills, while the Carse of Gowrie forms the low ground bordering the Firth of Tay towards Dundee.

Highland Railway.

From **Perth** we continue on the Old Red sandstone up the Tay Valley to near Dunkeld, where we enter the Highlands among the Grampian Hills.

Until we approach Inverness our route lies wholly among the old crystalline schistose rocks, varied only by the accumulations of glacial sands and boulder gravels, torrential valley deposits, and peat. There are comparatively few cuttings and tunnels.

From **Dunkeld** we pass over quartzites and mica-schists, up the Tay Valley to the Tummell Valley at Pitlochry, and thence by the Pass of Killiecrankie, along the Garry, through a more varied series of schists, with occasional limestones and slates, to **Blair Athole.** Schichallion (3547 feet) may be seen from near the Pass of Killiecrankie as we look up the Tummel Valley towards the W.S.W. Ben Vrackie rises to the east (2757 feet).

Leaving Blair Athole we proceed up Glen Garry, with the Forest of Athole to the north, to the Pass of Drumochter, where the railway attains a height of 1500 feet. We now descend by Dalwhinnie, with a peep of Loch Ericht to the south-west, and proceed along Strath Spey, a broad tract with much drift, by **Kingussie** and Kincraig, to Aviemore. Eastwards there is a fine view of the great granite mass which rises to form Cairn Gorm (4084 feet) in the northern part and Ben Macdhui (4296 feet) to the south.

If we follow the new line of railway we continue through a grand and rugged country of schists, crossing the Findhorn at Tomatin, and passing on to a granite mass at Moy. Near Daviot, by Strath Nairn, we enter a tract of Old Red sandstone, and continue on it by Culloden to **Inverness.**

Journeying past Grantown, we ascend through a tract of granite to Dava, and descend by Dunphail near the Findhorn to **Forres**, where we traverse the Old Red sandstone by **Nairn** to **Inverness**, through a low-lying fir-clad country.

Leaving Inverness, we skirt the shores of Beauly Firth, mostly on Old Red sandstone, with schists appearing at Lentran; and we continue on the Old Red sandstone through a well-cultivated country to **Dingwall**, and along the shores of Cromarty Firth to Invergordon.

From Invergordon we proceed on the Old Red sandstone to **Tain,** now skirting Dornoch Firth and passing on to granite and schists between Edderton and Bonar Bridge. Thence we traverse a region of schists to Lairg, and descend Strath Fleet through a granite area to Rogart. Again we cross schists and pass on to the Old Red sandstone at the Mound and **Golspie**, a formation which rises into bold hills along this part of the coast.

From Golspie, past Dunrobin Castle to **Brora** and Helmsdale, we traverse a strip of New Red and Jurassic rocks—the latter ranging from the Lias to the Kimeridgian, and perhaps Portlandian. They are exposed along the burns and in reefs on the foreshore, but elsewhere are largely concealed by various drift deposits. At Brora coal has long been worked in one seam in the Great Oolite series.

Leaving Helmsdale we cross a granite tract which forms the Ord of Caithness, and proceed mostly on schists to Kildonan—a locality at one time of notoriety on account of the gold found in the alluvial deposits.

Prominent hills of Old Red sandstone, the Maiden Pap (1587 feet) and Morven (2313 feet), are seen to the north-east, and indeed for some distance onwards.

We pass from Kinbrace and Forsinard through a granite country, and over schists and Old Red sandstone, forming a dreary moorland, to Halkirk and **Thurso**, or to **Wick**. Thurso is the centre of the Caithness flag industry, and Wick of the fishing-trade.

Dingwall to Kyle of Lochalsh.

From Dingwall we may proceed westwards by **Strathpeffer** on the Old Red sandstone, famed for its sulphurous waters. Ben Wyvis, a schistose mountain, stands bodly up to the north (3429 feet), and thence we traverse a grand mountainous country of schists, with many a highland loch and cascade, to Achnashellach, where the Torridon sandstone meets the Highland schists to the north of Strath Carron. We continue on the schists to Strome Ferry and then cross a tract of Torridon sandstone to the **Kyle of Lochalsh.**

Crewe to Holyhead.

Leaving **Crewe** for Holyhead we pass over a broad tract of
MAP **5** Keuper marls with Drift, to Beeston Castle, which is situated on the scarp of Keuper and Bunter sandstones. Thence to **Chester** we continue on the Bunter sandstone. The railway now traverses an alluvial flat at the head of the Dee
MAP **31** estuary, and continues alongside the estuary, which is bordered by the Flintshire coal-field, past **Flint** and **Holywell.** It now skirts the sea-coast, which is fringed with blown sand, by Prestatyn and **Rhyl**—across the lower part of the Vale of Clwyd, on to Coal-measures at Abergele and on to Carboniferous limestone beyond.

At Colwyn Bay Silurian rocks occur, but all along the strata are much obscured by drift. The headlands of the Ormes Heads by **Llandudno** and Puffin island, off Anglesey, are formed of Carboniferous limestone. At Conway Ordovician and igneous rocks appear, and a great mass of diorite stands out at Penmaenmawr. We cross Cambrian rocks at **Bangor,** and pass over Carboniferous limestone before we enter the Tubular Bridge. Thence in Anglesey we traverse a country mostly of schists, with Carboniferous rocks much concealed by drift in the low-lying district of Malldraeth Marsh, and further on schists and granitoid rock, with blown sands by Cymmeran Bay, serpentine near Rhoscolyn,and schists again at **Holyhead.**

VI. GREAT CENTRAL RAILWAY.

(*With Metropolitan Railway to Quainton Road.*)

London to Aylesbury and Sheffield.

From Marylebone the line passes through tunnels and cut-
MAP **2** tings of London clay to West Hampstead, and over the same formation past Willesden Green. In the Brent Valley, near Wembly Park Station, traces of Drift with remains of hippopotamus, were opened up during the construction of the railway. We continue on London clay past **Harrow**, the hill being capped by Bagshot beds.

Pinner is situated on an inlier of the Reading beds, a mixed formation of mottled clay, sand, and pebble-gravel, bordered by London clay. This is a well-timbered picturesque region, and a little further on we gain a glimpse of the Ruislip reservoir. Leaving Northwood we soon enter the Chalk country and cross the watery Colne Valley to **Rickmansworth.** Then we traverse a hilly and well-wooded region, with many beech-trees. The subsoil consists largely of gravel and clay-with-flints which fill huge irregular pipes in the Chalk. We enter the Misburn Valley near Amersham, proceeding by Great Missenden and through a cutting in the Lower Chalk and Chalk marl to Wendover. Here we pass from the head of the Misburn Valley, which is cut through the Chiltern Hills, into the broad Vale of Aylesbury formed largely of Gault and Kimeridge clay. The fine escarpment of the Chalk with its smooth outlines stands out boldly as we leave Wendover.

We now cross a flat country of arable and grass land to Stoke Mandeville, and get peeps of shallow cuttings in Portland beds as we approach **Aylesbury.** Beyond we pass over Kimeridge clay, and at Quainton Road, where the railway parts from the Metropolitan line, we are on the upper beds of Oxford clay, which yield large specimens of *Gryphæa dilatata.* Thence we traverse the Oxford clay with thin coverings of drift, and the Cornbrash, wholly concealed by boulder-clay and drift gravel, which are exposed near Finmere. Onwards we find occasional exposures of drift and Great Oolite, especially in cuttings on either side of the Ouse Valley by **Brackley,** where the soft white limestones and marls and hard shelly limestones of the Great Oolite are very fossiliferous. The harder beds have locally been used for building purposes. Through

MAP 22 Helmdon we pass fine cuttings in boulder-clay and Great Oolite, and observe also Estuarine clays and sands beneath the limestones. Further on, near Woodford and Hinton, we pass a large pit in drift gravel, and deep cuttings in the blue Upper Lias clay with cement-stones, and in boulder-clay, with also slipped masses of Northampton sands from Hinton Hill.

South of Charwelton we traverse a cutting in Middle Lias (marlstone) faulted against the Upper Lias clay. Near the station the clay is covered with drift gravel, and beyond we enter another cutting of Upper Lias faulted on the north against the Middle Lias. A little further on we enter the long **Catesby** tunnel excavated in the clayey beds of the Middle and Lower Lias. The cutting at the north end of the tunnel yielded many fossils of the zone of *Ammonites capriornus.*

MAPS 29, 19 Onwards past Willoughby we traverse cuttings in the Lower Lias clays, and then pass over a mass of drift sand and gravel before we enter **Rugby.** Thence to Lutterworth and Ashby Magna while crossing the Lias, and further on the Keuper marl by Whetstone to Leicester, the ground is much covered with boulder-clay and gravels.

At **Leicester** we cross the Soar Valley, and continue on Keuper marls with much drift. Our route lies between the rocky hills of Charnwood Forest and the granite area of Mount Sorrel which is just touched by the railway; and we pass Quorn and Woodhouse, and **Loughborough.**

MAP 24 We now cross a tract of Lower Lias limestones and Rhætic beds, the black Rhætic shales and underlying green and grey marls being cut through on the way to East Leake. Further on by Ruddington the Keuper marls occupy low ground with old swampy tracts that are filled with peat and sand. Ere reaching Nottingham we traverse a cutting in the marls.

Nottingham is situated on the Bunter pebble-beds, well seen at the Castle, and we continue on this formation to Bulwell. Thence by Hucknall Torkard we cross the Magnesian limestones and marls, on to Bunter sandstone with much drift at **Annesley,** and again through Permian at Kirkby-in-Ashfield, on to the Derbyshire coal-field at Pinxton, and onwards by Staveley to **Sheffield.**

MAPS 9, 30

VII. GREAT WESTERN RAILWAY.

London to Penzance, South Wales, Malvern, Shrewsbury, and Birmingham.

MAP 2 Leaving Paddington we traverse the London clay to Acton and thence for some distance by Ealing, Southall, West Drayton and Slough, the gravels and brickearth of the Thames Valley. These form a broad vale, marked by numerous brickyards, as at Langley, and occasional gravel pits. The deposits in this area have not yielded so many mammalian remains, as have those lower down the valley: but remains of mammoth were in the early days of geology obtained at Brentford, and palæolithic implements have been found near **Ealing.** Market gardens and nurseries have been established over many parts of the area. Near **Slough** we have peeps of Windsor Castle, which is built on an eminence of Chalk, here bent into anticlinal form. Beyond Slough we cross the outcrop of Reading beds on to Chalk, both hereabouts concealed by valley gravel. At Taplow phosphatic bands have been observed in the Chalk. We now cross the Thames and pass **Maidenhead,** where the valley gravel above the Chalk has yielded remains of Musk-Ox.

MAP 3 The Lower Eocene strata, London clay and Reading beds occur to the south of the railway, and a large outlying mass extends to the north of Twyford, near Wargrave.

We cross portions of these strata at Twyford and onwards towards **Reading,** where the red brick houses exhibit one of the local industries: the mottled clays of the Reading beds having long been utilized for brick-making.

From Reading we keep on the Chalk with overlying valley gravels, the Chalk being exposed in deep cuttings here and there as we pass through Pangbourne and Goring to Moulsford—through what is called the gorge of the Thames. The river has here trenched the escarpment which north-eastwards forms the range of the Chiltern Hills. Beyond Moulsford we traverse the Chalk marl, a low-lying tract, and then cross the outcrop of Upper Greensand which rises gently above the plain of Gault beyond, and reach **Didcot**, situated near the junction of the two formations.

The Chalk escarpment stands out boldly to the south, and near Uffington, beyond Wantage, is the celebrated White Horse, formed by the cutting away of the turf on the Chalk slope; this gives name to the Vale we now traverse, and which is formed partly of Gault and partly of Kimeridge clay.

At **Faringdon** (on a branch line), are the sponge-gravel beds of the Lower Greensand, and we cross portions of this formation beyond Uffington on to the Kimeridge clay, which extends as a low-lying tract of meadow land for some distance.

MAP 14

Swindon Station and new town are situated on the Kimeridge clay, which is largely worked for brick-making and noted for saurian remains. On high ground to the south the old town stands on the Portland beds, which yield bands of hard sandstone (Swindon stone), and other layers, rich in fossils. Cappings of Purbeck beds are also present.

At **Wootton Bassett** the Corallian beds pleasantly diversify the scenery, forming a scarp which overlooks the broad vale of Oxford clay, which extends by Dauntsey to Chippenham. Beyond Dauntsey is Christian Malford, and here many ammonites and other fossils were obtained during the construction of the railway, especially from trenches made to obtain material for the long embankments. Further on to the south lies Kellaways, famed for its beds of fossiliferous sandstone which were dug for road-metal in old days. The Kellaways Rock occurs near the base of the Oxford clay, and may be seen in the banks of the stream below Kellaways Mill.

Leaving **Chippenham** which is situated partly on the Cornbrash, we enter upon the Lower Oolites, that form the southern extremity of the Cotteswold Hills, and the fine bold scenery which we traverse on the way to Bath. It is a country of stone-fences and stone-built houses. At **Corsham** we pass cuttings in the Forest Marble and at the entrance to the Box tunnel, layers of fossiliferous Bradford clay overlie the massive limestones of the Great Oolite. The tunnel is excavated through this formation, and also through the Fuller's earth and Inferior Oolite. The large quarries of Corsham and Box are in reality mines whence the Bath Stone (Great Oolite) is obtained from underground tunnels, whose extent now collectively amounts to upwards of thirty miles in length.

MAP 11

Bath is situated on Lower Oolites, Lias, and valley gravels; the gravels have yielded remains of mammoth. We pass over the Lias at Twerton, crossing the Keuper marl and a tract of Coal-measures at Newton St. Loe. The bold scarp of the Cotteswolds terminates at Kelston Round Hill on the north. At Saltford we enter cuttings of the blue Lower Lias and the White Lias (Rhætic beds), and we continue on Lower Lias with fine cuttings near **Keynsham**. Beyond we enter the Bristol coal-field and pass through cuttings and tunnels of the Pennant Grit (Middle Coal-measures) which forms fine wooded scarps. By St. Anne's Park the softer Keuper (New Red) sandstone may be seen resting unconformably on the red Pennant Grits. Leaving **Bristol** we have glimpses of the Clifton Suspension Bridge which crosses the Avon lower down, and we pass a deep cutting in the Keuper marls and overlying Rhætic beds at Bedminster. We continue on the Keuper marls bordered by Carboniferous limestone, which extends to the north from the Clifton gorge; and soon enter the Nailsea coal-field which is fringed on the south by the Carboniferous limestone famed for its combes of Brockley and Cleve. At **Yatton** we pass on to the alluvial moors that border the estuary of the Severn as far as Durston, beyond Bridgwater: a region that includes rich grazing lands, and also large tracts that are liable to be flooded after long-continued rain. We have fine views of the Mendip Hills, and at Uphill we traverse the western extremity of the range in a cutting which shows the Keuper marls, Rhætic beds and Lower Lias on the north, faulted against the Carboniferous limestone on the south. Eastwards Crook Peak, one of the Mendip Hills, stands out prominently, and further east are the Cheddar Cliffs. To the west is Brean Down.

We now pass the bold hill of Middle and Upper Lias and Midford Sands, known as Brent Knoll, and on a clear day we may discern far to the east the smaller conical knoll of Glastonbury Tor, of similar structure, and both relics of wide-spread denudation. Passing **Highbridge,** we cross the western end of the Polden Hills at Dunball, where the Blue Lias is worked for lime and cement, and the cutting shows also the Rhætic beds below. At **Bridgwater** we cross the River Parrett, the "slime" from which is utilized in the manufacture of Bath bricks. Beyond Bridgwater to the east, on part of Sedgemoor, lies the little Isle of Athelney, and now we soon enter the fertile Vale of **Taunton,** formed of New Red marls, sandstones, and conglomerates; bordered on the north-west by the Devonian rocks of the Quantock Hills, and on the east or south-east by the Upper Greensand heights of Blackdown, upon a spur of which the Wellington Monument is situated. Leaving Wellington

MAP 10

we traverse a tunnel in New Red rocks, and at Burlescombe observe fine quarries in contorted limestones of the Lower Carboniferous. At **Exeter** we note sections of the Culm-measures (see p. 129). Beyond we proceed along the borders of the Exe estuary, with the red sandstones of Exmouth on the east, and the Haldon Hills (Upper Greensand) on the west. At **Dawlish** and **Teignmouth,** the railway runs at the foot of fine cliffs of Permian sandstone, breccia, and conglomerate, and thence borders the estuary of the Teign to **Newton Abbot.** Here in the higher part of the valley are the Eocene clays so largely worked for the potteries, and the interesting lignite-beds of Bovey Tracey. Beyond Newton we come to the Devonian limestones and slates, and thence by Totnes as far as Plymouth the line passes for the most part over the

MAP 6

Devonian slaty rocks, the granitic range of Dartmoor being skirted on its southern margin. At **Plymouth** the Devonian limestones are well developed, and thence into Cornwall we pass over a country chiefly made up of Devonian slates or "killas," and granite, with a cutting in altered dolerite and serpentine at Menheniot.

Perhaps the most picturesque portion of the railway is that near **Bodmin Road,** where the bold hills that lie south of the granite of

Bodmin Moor are well wooded. At Lostwithiel we pass near Restormel Castle, and its once famous iron-mines. At **St. Austell** we are in the midst of china-clay works, and may note the milky appearance of the streams which issue from them. Thence we pass through a slaty region to **Truro**, with deep and picturesque valleys and bold rounded hills with much grassy and arable land. The fields are divided by stone and earth banks, capped often by gorse and other bushes, and even by small trees. We traverse the chief mining region at **Redruth** and **Camborne**, and here the streams are red rivers, being stained with ferruginous mud from the washings of the tin-mine works. Mines in activity and mines deserted, with heaps of refuse, characterize this region. The rugged granite hill of Carnbrea lies to the south. We pass over agricultural tracts with few trees, and through a cutting in greenstone on the way to Gwinear Road, and at Hayle we look towards the blown sand hills of Lelant and Phillack, with old mines, and thence reach St. Erth. On the hills to the east there is a remnant of Pliocene (Crag) deposits.

Proceeding to **St. Ives**, we pass along the margin of the tidal creek, which is bordered by dark slaty cliffs with grassy slopes, to the white sandy Carbis Bay, and through cuttings of slate and greenstone to St. Ives.

Proceeding to **Penzance**, we pass on to Marazion, with a fine view of St. Michael's Mount (granite) to the south-east, and thence to the granite region of Penzance. Here the hills, if bold, are not lofty, and the ground is extensively cultivated, the enclosures being small on account of the shelter afforded by the banks of earth and stone.

Wootton Bassett to South Wales.

MAP 14 From **Wootton Bassett** we traverse a cutting in Corallian rocks and then proceed across an undulating low-lying tract of Oxford clay, past Brinkworth to Little Somerford, where Kellaways beds were exposed. We now cross the Avon, and pass through other cuttings in Oxford clay and Kellaways beds near Corston, on to the Cornbrash at Hullavington. Thence we traverse a grassy country of Forest Marble, with cuttings in clays and limestones and sandy beds, faulted here and there, and through a short tunnel and deep cuttings, which expose the Great Oolite below, by Alderton to the south of Badminton. Further on, near Acton, Turville, we pass through a long tunnel excavated in Forest Marble, Great Oolite, Fuller's earth, Inferior Oolite, and Lias, and we emerge below the scarp of the Cotteswold Hills, near Old Sodbury.

Westwards we pass through cuttings in Lower Lias limestones and clays, and Rhætic beds, with Cotham marble, to **Chipping Sodbury.** Thence are exposed Old Red sandstone, Carboniferous limestone with bands of grit, and overlying Rhætic beds and Keuper marls. Further on we traverse fine cuttings in Rhætic beds, and Red marls with celestine, and then cross the Bristol coal-field with deep cuttings in the Pennant grit, and cuttings in red, yellow, and purple shales. Beyond **Winterbourne** we again come on Red marls, Rhætic beds and

Lias near Stoke Gifford and Patchway. Then we pass tracts of Carboniferous limestone and faulted Coal-measures at the Cattybrook brick and tile-works, before crossing the broad alluvium of the Severn flats to the Severn tunnel. This tunnel (more than four miles long) was excavated partly through Millstone grit, Coal-measures,
MAP 16 and Triassic rocks. On emerging from it we traverse cuttings in Keuper marl and sandstone bordered by Carboniferous limestone, and skirt the alluvial moors by **Newport** to Cardiff. We pass quarries in the Lower Lias at Liswery near Llanwern east of
MAP 32 Newport, while the higher grounds are formed of Old Red sandstone with Silurian at Rumney, near Cardiff.

From **Cardiff** our route lies over a region of Dolomitic conglomerate and Lower Lias, much drift-covered, past St. Fagans. Near **Llantrissant** we cross the Carboniferous limestone, which here yields iron-ore in pockets, and pass over a portion of the great South Wales coal-field, on to the Red marls and Lower Lias again at **Bridgend.** The Lias is here extensively worked for lime and cement making. We continue on the Lias, Rhætic beds, and Red marls to Pyle, and then traverse the alluvium fringed by blown sands, on the borders of the Coal-measures, to **Neath** and **Swansea.** The bolder hills are here formed of the Pennant grit. Leaving the dreary mining and smelting region of Landore near Swansea, we pass the western portion of the coal-field at **Llanelly** and Kidwelly on the borders of Carmarthen Bay, with its fringes of blown sand. At **Kidwelly** we cross the Lower Carboniferous rocks, proceed up the Towy Valley on Old Red sandstone, and near **Carmarthen** enter a tract of Silurian and Ordovician rocks which extends westwards to near Haverfordwest. From **Haverfordwest** we cross Silurian rocks on to the Coal-measures of the Pembrokeshire coal-field, traverse igneous rocks by Johnston, and thence we pass over a belt of Silurian on to Old Red sandstone upon which **Milford Haven** is situated.

Swindon to Great Malvern.

From **Swindon** to Gloucester we leave the Kimeridge clay
MAP 14 near Purton and cross the scarp of the Corallian rocks on to the broad vale of Oxford clay, formerly part of the Forest of Braydon. Near Kemble we cross the outcrop of the Cornbrash, and pass through cuttings in Forest Marble and Great Oolite. Fossiliferous Bradford clay was exposed below the railway where it crosses the Roman road (Akeman Street) between Tetbury and Cirencester. We now traverse the Cotteswold Hills, a region of stone-fences, stone-built and sometimes stone-tiled houses. Cuttings in Great Oolite and the long Sapperton tunnel are passed through, the tunnel traversing Great Oolite, Fuller's earth, and Inferior Oolite which is exposed at the northern entrance. We now descend the beautiful Stroudwater Valley, past Chalford, noted for its springs, on to the Upper Lias at **Stroud.** To the south is Minchinhampton Hill, famed for its Great Oolite fossils, while the slopes formed of Inferior Oolite are everywhere rich in organic remains. Passing brickyards in Middle Lias we traverse a vale of Lower Lias to **Gloucester.** Crossing the

Severn we pass a cutting in Lower Lias and Rhætic beds at Lassington, on to the Keuper marls. May Hill, formed of Silurian rocks, lies to the south-west, and the Malvern range stands out to the north. At **Newent** we cross a tract of Keuper sandstones and marls, and a narrow belt of Coal-measures near Oxenhall. Thence by Dymock to Ledbury we pass over Old Red sandstone.

MAPS 16, 29 At **Ledbury** we traverse the passage-beds into the Silurian, in the cutting and tunnel, where the Ledbury shales are followed by Downton sandstones and Ludlow beds. At Colwall we cross another portion of Old Red sandstone, and now traverse the Silurian rocks and the old gneiss of Malvern in a tunnel whence we reach the vale of Keuper marls on the east of the range of hills at **Great Malvern.**

Didcot to Worcester and Shrewsbury.

MAP 3 From **Didcot** we traverse the vale of Gault to the borders of the Thames, cross a tract of Lower Greensand, and again pass over the river to the junction for Abingdon. Thence we continue over a flat tract of Kimeridge clay and Corallian rocks, with valley gravel and alluvium, to **Oxford.** Eastwards we have a view of Shotover Hill, capped by Lower Cretaceous. From Oxford we pass large brickyards in the Oxford clay capped by valley gravel. We continue through a flat tract, liable to extensive floods after much rain, with a view westwards of the wooded hill of Corallian rocks at Wytham, and past Yarnton, where there is much valley gravel, into the Evenlode valley.

At Handborough we enter the Oolite country, and notice the stone-built and stone-tiled houses. Not far off to the north are the famous pits in Stonesfield Slate. Thence we pass cuttings in the Great Oolite series—white limestones and clays, and cross the representatives of the Inferior Oolite to Charlbury. At Fawler the ironstone of the Middle Lias has been worked. Here we traverse the Lower Lias clays, the bordering hills being formed of Oolites. Wychwood Forest, a tract of Forest Marble, forming part of the Oxfordshire Downs, rises to the south-east of Shipton-under-Wychwood.

MAP 14 The clay vale widens gradually as we pass **Chipping Norton** Junction on to Moreton-in-the-Marsh, with its brick-built houses. Here there are scattered gravels. The bold hills of the eastern Cotteswolds (Inferior Oolite) lie to our west and uplands of Oolite rise to the east. The railway now traverses more diversified scenery, with rich pastures and fine trees—and an occasional brickyard in the Lower Lias, as near Blockley.

A mass of boulder-clay was cut through at Aston Magna. Further on we cross a spur of the northern Cotteswolds at **Chipping Campden,** thence through a tunnel in Middle Lias, and to the Lower Lias plain of Honeybourne. Crossing the Avon at

MAP 29 **Evesham,** we proceed by Fladbury and Pershore, through a fruit and market garden district, where the heavy clays of the Lower Lias are rendered fertile by coverings of valley gravel.

The Inferior Oolite of Broadway on the northern Cotteswolds, and the bold outlying hill of Bredon are conspicuous, to the south-east and south-west of Evesham.

At Norton Junction we are on the red Keuper marls, and we continue on them through **Worcester**, traversing a fine cutting in red and variegated marls with irregular bands of green marl, and an undulating grass country, past **Droitwich**, with its salt-works, to Hartlebury, on the Keuper sandstones. Beyond this we

MAP 25 traverse Bunter sandstone, passing Stourport with fine hills and cuttings to **Bewdley**, on the Severn.

We now enter the borders of the Wyre Forest coal-field, and through Arley and Highley pass through a rougher country, with cuttings in hard grey sandstone and shale, and occasional coal-seams. Here and there Permian red breccias and sandstones are traversed. There are several sections of these as we leave the coal-field at Hampton Loade and Eardington. At **Bridgnorth** the Bunter sandstone appears, and fine cliffs are seen bordering the Severn. We again traverse Permian rocks and enter the Coalbrookdale coal-field at Linley, passing wooded tracts and cuttings in grey sandstones, on through the busy districts of **Coalport, Ironbridge,** and **Broseley** with their coal and ironworks and brickyards.

We now enter a region of Silurian and older rocks. Benthall Edge to the south-west is formed of Wenlock limestone, and **Buildwas** with its Abbey is on the Wenlock shales. We thence pass over a tract of Cambrian rocks at Shineton, Cressage and Harnage.

The Wrekin, formed of Cambrian quartzite and Uriconian volcanic rocks, stands out in dome-like form to the north-east, while the bold mountainous tract of Church Stretton, with the Longmynd and Caradoc Hills may be seen to the south-west.

After traversing a low-lying country of Bunter with drift, along the Severn borders, we pass over belts of Pre-Cambrian and Coal-measures on to the Permian of **Shrewsbury.**

Oxford to Warwick and Birmingham.

MAP 3 From Oxford to Birmingham we traverse a tract of Oxford clay with large brickyards, and coverings of gravel, past Wolvercot, and up the valley of the Cherwell. At Kirtlington and Bletchington there are cuttings in blue clays and limestones of the Great Oolite series. Further on, near Heyford, we leave the escarpment of the Oolitic series and enter the region of Lias, with

MAPS 22, 3 hilly ground formed of a platform of Marlstone. This rock yields iron-ore near **King's Sutton,** and generally in the area it makes a notable reddish-brown soil. The houses at **Banbury** are largely built of brown and greenish varieties of the rock, which yields a good freestone at Edgehill. Beyond Banbury we continue on a tract of Lower Lias clays past Fenny

MAP 29 Compton, where many fossils have been obtained, to the Lower Lias limestones, exposed in the cutting and in quarries at Harbury, where the stone is used for lime and cement-making. Beyond this we cross the Keuper marls to **Leamington,** and the

Keuper sandstones at **Warwick**, and then pass over an undulating and, for the most part, low-lying tract of Keuper marls, with much drift, until we reach **Birmingham**.

VIII. LONDON AND SOUTH WESTERN RAILWAY.

London to Portland, Ilfracombe, and Portsmouth.

MAP **28** Leaving Waterloo Station, we pass over the Lower Eocene strata to near Walton-on-Thames, noting sections of Thames Valley gravel at Clapham Junction, and of London clay near Wimbledon and Surbiton. Crossing a portion of the Thames Valley, we enter upon the sandy, fir-clad and heathy country formed by the Bagshot beds, that extend from near Walton and Hersham, by Weybridge, **Woking**, and Brookwood, past the Chobham Ridges, to beyond Farnborough. Near Weybridge there is a fine section of Bagshot sands resting on London clay, and covered by an irregular accumulation of gravel. Picturesque pools of water, held up by clayey beds in the Bagshot series, diversify the scenery here and there as near Fleet. A few miles south of Fleet is the military station of Aldershot.

MAP **15** At **Basingstoke** we come on the Chalk, and thence cross an open undulating tract with scanty hedgerows, wooded hollows and plantations here and there, and thinly populated. We traverse occasional tunnels and cuttings in this formation, through Micheldever to **Winchester**. Near Shawford, old terraces of cultivation (lynchets) may be observed.

About four miles south of Winchester we enter the Tertiary tract of the Hampshire Basin, passing along the valley of the Itchen River, across outcrops of Reading beds and London clay, to Eastleigh and Bishopstoke, on to the Bagshot series, which covers a considerable area around **Southampton**. The ground here is lower and more wooded. At St. Denys we pass the tidal waters of the Itchen, and beyond, at Southampton West, we have views of the old town wall and of Southampton Water, with its mud flats at low tide. The new docks were excavated through estuarine mud with *Scrobicularia* and fresh-water deposits into Bracklesham beds.

MAP **11** Through Totton and Elling we cross a low-lying pastoral country, bordering the New Forest, with its heaths and woodlands and here and there cultivated tracts, and traverse cuttings in loams and brown and white sands, past Lyndhurst Road, Brockenhurst, and Ringwood, to **Wimborne** Junction, where we come into more cultivated regions. We cross the Stour, and thence proceed through cuttings in sands and white clays by Broadstone Junction, with peeps of Poole Harbour and of the Chalk range of Purbeck to the south, on to Hamworthy Junction.

MAPS **15, 11** If we journey from **Brockenhurst**, *viâ* Bournemouth, to Hamworthy Junction, we cross the Avon, which flows out to sea east of Hengistbury Head, through **Christchurch** and **Bournemouth**, and along the borders of **Poole** Harbour, whence various pottery clays are shipped. At Hamworthy Junction, and again near Moreton, the clays are worked for bricks and tiles. The cuttings for the most part show sands capped by gravel.

As we pass through **Wareham** we obtain a view of Corfe Castle, on a knoll in the Chalk ridge, while westwards rises the prominent Bagshot outlier of Creech Barrow (see p. 49). The scenery is alternately wild, with extensive heaths, or cultivated with tracts of woodland. Then we traverse cuttings in the Chalk, and reach **Dorchester.** Near the station are earthworks in the form of an amphitheatre, and beyond is the old camp known as Maiden Castle. We traverse a tunnel in the Chalk, at the southern mouth of which, near Upway, we come upon Wealden and Purbeck beds faulted against the Chalk. Further on we pass quarries in the Purbeck and Portland beds, cross a belt of Kimeridge clay on to Corallian at Broadway, and soon get a view of Weymouth Bay. On the borders of the Backwater or Radipole Lake we traverse the Oxford clay with septaria, and enter **Weymouth.** At Rodwell we pass through a cutting in the Corallian beds, and pass along the Chesil Beach to Chesilton in **Portland.**

Basingstoke to Exeter and Ilfracombe.

MAPS 15, 11 From **Basingstoke** we traverse the Chalk through Whitchurch and Andover to **Salisbury.** Thence we pass Fisherton and its brickyards with Pleistocene fossils. Beyond Wilton we enter the picturesque wooded Vale of Wardour, which is bounded by the escarpments of Upper Greensand and Chalk. The Upper Greensand forms the conspicuous heights further west at Fonthill Abbey, north of Tisbury, and at Wardour Castle and Shaftesbury on the south. At Dinton we cross the Wealden on to the Purbeck beds, and thence on to the Portland beds, which are extensively quarried for building-stone at Chilmark and **Tisbury.** The bordering Upper Cretaceous strata here overstep the outcrops of the Wealden and Jurassic divisions. As we proceed westwards we traverse the successive escarpments formed by the harder stony Jurassic beds. Leaving Tisbury we pass on to the Kimeridge clay, which forms a broad vale through Semley and Gillingham—a tract mostly of pasture land with occasional brickyards. Beyond Gillingham we enter a cutting and pass through a tunnel in the Corallian rocks, which form a scarp overlooking another tract of flat meadow land—a well-known hunting country—the Vale of Blackmore formed of Oxford clay.

At **Templecombe** we reach rising ground formed of the Cornbrash which is seen in shallow cuttings, and further on the Forest Marble clays are exposed. This formation forms a prominent escarpment in Dorset, owing to the bands of flaggy oolitic limestone, which constitute the central portion of it. Further on we enter low ground occupied by the upper part of the Fuller's earth clay, and then traverse a cutting and escarpment formed by the Fuller's earth rock. Beyond we pass through Milborne Port on to the Inferior Oolite, which is richly fossiliferous in this district, at **Sherborne** and Bradford Abbas. East of Sherborne we cross the alluvial flats of the Valley of the Yeo, while further on at **Yeovil Junction** there are fine sections of the Yeovil (or Midford) sands, which lie below the Inferior Oolite limestones. At Sutton Bingham we pass across a faulted tract of Cornbrash and Forest Marble and low ground formed of Fuller's earth, while at **Crewkerne** we traverse Inferior Oolite and sands, with hills of Chalk and Greensand to the south. Further on we enter the broad outcrop of Lias with coverings of Upper Greensand which form the hills on either side of the railway, those of Lewesdon and Pillesdon Pen on the south being MAP 10 very conspicuous. Then by **Chard** Junction we proceed along the Axe Valley past a fine ballast pit near Broom, which has yielded many palæolithic implements formed of chert, and thence across the Lower Lias limestones to **Axminster.**

Axminster is noted geologically as the residence for some time of the Rev. W. D. Conybeare, who was vicar there before he became Dean of Llandaff. The town is situated near the junction of the Rhætic beds and the Keuper marls. A light railway to **Lyme Regis** passes across these beds and over valley gravels and through cuttings in Upper Greensand and slipped masses of chert detritus, and near Combe Pyne through white sands and white and coloured clays and gravels that belong to the Bagshot series.

Proceeding from Axminster we pass over the Keuper marls with bordering hills of Upper Greensand towards Honiton, and in the cutting at the eastern end of the long tunnel are traces of Gault at the base of the Greensand. At **Honiton** the escarpments of the Upper Greensand are very bold, and near Broadhembury to the north, some of the fine cherty sandstones have been worked for scythe-stones.

From Honiton we cross the Otter Valley on to the Red sandstones of the Keuper, and beyond **Sidmouth Junction** onwards to Exeter, we traverse for the most part the marls, sandstones and breccias of the Permian, with faulted tracts of the Budleigh Salterton pebble-bed (Bunter) between Sidmouth Junction and Whimple.

Exeter is situated partly on the Culm-measures with some volcanic rocks, and partly on Permian breccias which are largely quarried at Heavitree. Thence in travelling to Barnstaple we pass over the grits and shales of the Culm-measures to St. Cyres', traverse a tract of Permian with contemporaneous volcanic rocks at **Crediton,** and again cross Culm-measures, which form a boldly undulating country by Eggesford and Chumleigh, and along the Taw Valley, to **Barnstaple.** Valley gravel is seen by the Chapelton Station. The town is situated on the Upper Devonian rocks. Beyond we pass along the borders of the Taw estuary to Braunton, with a view over the Braunton Burrows (blown sands), and traverse a bold hilly country mostly of Devonian grits and slates to **Ilfracombe.**

Woking to Portsmouth.

From **Woking** to Guildford we cross an area of Bagshot beds, MAP 28 with cuttings in white and brown sands, and tracts of valley gravel in the lower grounds, past Worplesdon on to the London clay, and thence across a belt of Reading beds to the Chalk

at **Guildford** Station. We pass through a tunnel in the steeply inclined Chalk of the Hog's Back, across a narrow belt of Upper Greensand and Gault, and a tract of Lower Greensand, on to the valley gravel of Pease Marsh on the borders of the Wey. Here an inlier of Wealden beds is partially exposed, but we pass again on to the Lower Greensand at Farncombe, cross the Wey to **Godalming**, and thence continue on the same formation to Witley. Here we traverse a tract of Weald clay which occupies the vale, bordered on the west by the picturesque sandy hills of Hind Head. We re-enter the tract of Lower Greensand at **Haslemere**, the lower beds consisting of the Atherfield clay, which is occasionally worked for brick-making, and we continue through a sandy country to **Petersfield**.
MAP **15** Thence we cross a belt of Gault and Upper Greensand, traverse the Chalk of the South Downs to Rowland's Castle, and proceed across Reading beds and London clay to Havant (see below). From Havant we cross a drift-covered tract of Chalk and Eocene strata to **Portsmouth**.

IX. LONDON, BRIGHTON AND SOUTH COAST RAILWAY.

London to Portsmouth and Brighton.

Travelling from London Bridge to Dorking we cross the
MAP **28** Woolwich beds at Peckham and Dulwich, and then over the London clay and through tunnels in the same formation to Streatham. Further on at Mitcham we cross tracts of valley gravel, and passing over the Woolwich and Thanet beds reach the Chalk between Carshalton and **Sutton**. Thence by Cheam to Ewell and Epsom we keep near the junction of the Chalk and Lower London Tertiaries, with cuttings in Thanet sand, beyond which we cross a tract of London clay to **Leatherhead**. We now travel up the beautiful valley of the Mole, here excavated through the Chalk of the North Downs, the escarpment of which is marked by Box Hill. **Dorking** Station is situated on the junction of Chalk marl and Upper Greensand. Thence we cross a narrow belt of Upper Greensand and Gault, on to the Lower Greensand, and through a tunnel in that formation to the undulating, well-timbered tract of Weald clay by Holmwood and Ockley. Near **Horsham** we cross the anticline of the Hastings sand, part of St. Leonards and Tilgate Forest, and again pass on to Weald clay by the new station for Christ's Hospital. Lower Greensand is met with as we approach **Pulborough**, and this formation comprises sands, and clays worked for brick-making. We continue partly on it and partly on Gault, along the Arun Valley to Amberley. Once more we cross Upper Greensand on to the Chalk which extends to **Arundel**. Here the Lower Eocene beds of the Hampshire Basin occupy a syncline, and the Chalk again occurs to the south concealed by drift. In this region, indeed, from near
MAP **15** Arundel to **Havant** and Portsmouth, both Chalk and Eocene beds are almost wholly concealed by chalky gravel (Coombe rock) and brickearth. It is a flat but fertile agricultural tract with many market gardens. Beyond Havant we cross an alluvial tract to the island region on which **Portsmouth** is situated.

London to Brighton.

MAP 28 Leaving London Bridge we pass at a high level above houses built on alluvium and valley gravel. Crossing the Woolwich beds near New Cross we pass through an undulating country of London clay with here and there cuttings by Sydenham and Norwood, and across a gravelly tract overlying the Lower Eocene strata to **Croydon**, which is situated near the junction of Thanet sands and Chalk. Park Hill, which rises to the east, is formed ot the Blackheath pebble-beds. We now enter the Chalk country, passing at Purley Junction through cuttings and by large pits in this formation, and further on through a tunnel. Then leaving the bold Chalk escarpment of the North Downs we enter upon the Wealden area, noticing near **Merstham** the workings in Lower Chalk, and a cutting south of the tunnel in Upper Greensand. Below the gentle scarp formed by this deposit, which has long been worked for hearthstone and firestone, we cross flat ground formed of Gault which is worked for brick-making at Merstham. The clay extends near to **Red Hill Junction**, where we reach the Folkestone sands of the Lower Greensand, which rise in picturesque hills. In the area to the south of the junction is a belt of clayey Sandgate beds, which eastwards at Nutfield are worked for Fuller's earth. These are not seen on the railway. Thence we traverse a cutting in the Hythe beds, south of Redhill, and enter the low-lying tract of Weald clay which extends from Earlswood by Horley to **Three Bridges.** Patches of valley gravel occur here and there. Leaving Three Bridges we pass through cuttings and tunnels of Tunbridge Wells sand and sandstone (Hastings beds) with beds of Grinstead clay, by Balcombe and **Haywards Heath.**

At Wivelsfield we have crossed the centre of the Wealden anticline, and are again on the Weald clay as we journey on through Burgess Hill. North of Hassocks we pass on to Lower Greensand, and about half a mile south of the station we cross belts of Gault and Upper Greensand on to the Chalk of the South Downs, so well seen at Ditchling Beacon to the east, and in the fine combe known as the Devil's Dyke to the south-west. Thence we traverse tunnels and cuttings in Chalk past Preston to **Brighton.**

X. SOUTH EASTERN AND CHATHAM RAILWAY.

London to Hastings, Folkestone, Ramsgate, Dover, Queenborough, Maidstone, and Port Victoria.

MAP 17 Leaving Charing Cross we travel over alluvium by London Bridge and Bermondsey, and further on Thames Valley gravel and brickearth. At New Cross we traverse cuttings in the Woolwich and Reading beds, and pass on to the Chalk by St. John's near the well-known excavations of Loam-pit Hill, Lewisham. The elevated ground of Blackheath rises to the east. Thence we cross a tract composed mostly of London clay, which is shown here and there in the cuttings, until near **Chiselhurst,** the Blackheath beds, formed of pebble-gravel and sands, give rise to a picturesque area. Beneath the Woolwich and Thanet beds the Chalk is exposed here, and was worked in the tunnels of Chiselhurst cave. Beyond this we soon reach the Chalk at Orpington, and traverse it through a flat well-timbered country, with a hilly tract by Chelsfield, south-west of which is Down, long the residence of Darwin. The Chalk presents smooth hills, with thin scanty hedgerows; here and there it appears quite bare at the surface, elsewhere the agricultural features are modified by coverings of clay-with-flints, brickearth, and gravel. Knockholt (783 feet), south-west of Halstead, is noted for its beeches. On either side of Halstead Station there are fine cuttings and tunnels in the Chalk. Further on we emerge below the scarp of the North Downs, and cross a narrow outcrop of Upper Greensand east of Chevening, and then pass on to the low-lying tract of Gault worked for brick-making at Dunton Green. Leaving this we soon enter the higher ground of Lower Greensand, passing cuttings in the Folkestone sands, in the midst of which **Sevenoaks** is situated. A fine cutting in the somewhat false-bedded Kentish Rag and hassock is exposed south of the station. Further on we enter a tunnel cut through these rocks and Atherfield clay, and emerge on the plain of Weald clay. This generally low-lying, but undulating and wooded tract, extends by Hildenboro' to Tonbridge. Hop-grounds are seen here and there. **Tonbridge** itself is situated partly on the Tunbridge Wells sand with beds of rock sand. Thence we pass through a picturesque country composed of the Hastings beds (Ashdown sand, Wadhurst clay and Tunbridge Wells sand). The last-named division is well seen in the natural rocks at **Tunbridge Wells.** Onwards we pass over varied divisions of the Hastings beds, the clays of Wadhurst having yielded much of the Wealden iron-ore. Traces of the underlying Purbeck beds appear north of **Battle**, and about three miles to the north-west is the site of the Sub-Wealden Boring. Between **St. Leonards** and **Hastings** we pass through tunnels in the Hastings beds.

Tonbridge to Folkestone.

Proceeding from **Tonbridge** to Folkestone we cross a tract of Hastings beds (rock-beds, sands, and clays) and traverse the Weald clay, past Pluckley with its brick and tile works to the Lower Greensand at **Ashford.** Thence by Smeeth, Westenhanger, and Sandling Junction we pass over a diversified tract of Lower Greensand, with views of the Chalk downs to the north, to the central station at **Folkestone.**

London to Ramsgate.

From Holborn or Victoria we cross Thames Valley gravel
MAP **17** and London clay, with a tract of Woolwich beds at Dulwich. Then passing through a tunnel in the London clay at Penge, we traverse the Blackheath pebble-beds at Beckenham, Shortlands, **Bromley**, and Bickley, for the most part a picturesque residential district. Thence we pass over Woolwich and Reading

beds, and through cuttings of buff Thanet sands to **St. Mary Cray,** where the Cray Valley, occupied partly by valley drift, is excavated down to the Chalk. Onwards to Swanley we traverse Woolwich beds and Thanet sands, and then Chalk and outliers of Thanet sands with indurated beds, to Farningham Road. We now enter an open Chalk country, the cuttings showing Chalk with occasional pipes, while brickearth and gravel occur in the valleys. From Sole Street to Strood we traverse cuttings in Chalk, and soon enter the fine valley of the Medway bordered by steep slopes. Crossing the river to **Rochester** we pass cuttings and tunnels in the Chalk at **Chatham,** and from Rainham onwards to Sittingbourne and Faversham traverse a region of Thanet, Woolwich and Reading beds, and here and there Chalk, with coverings of valley brickearth and gravel. **Sittingbourne** is a region of brickyards; further on we find hop-grounds and occasional fruit and vegetable gardens. Chalk is exposed at **Faversham,** and we cross tracts of Lower Eocene, and alluvium on the way to Whitstable. From **Whitstable** to **Herne Bay** the route lies mainly over the London clay. Further east we pass near the ruined church of Reculvers, and cross the marsh and meadow lands which isolate the Isle of Thanet. The railway runs at a high level past Birchington and Westgate-on-Sea, through cuttings of Chalk with piped surface and patches of loam, on to **Margate** and **Ramsgate.**

Faversham to Dover.

From **Faversham** to **Canterbury** and Bekesbourne we continue on Chalk covered here and there by Thanet beds, and beyond we traverse a Chalk country to **Dover.**

Sittingbourne to Queenborough.

From **Sittingbourne** to Queenborough we cross the Thanet and Woolwich beds on to London clay, then pass over the Swale and the bordering alluvial meadows which divide the Isle of Sheppey from the mainland. **Queenborough** is on London clay, which is well shown in the cliffs that extend from the east of Sheerness to Warden Point. There numerous landslips have taken place, and many fossils have been obtained from the London clay.

Swanley to Maidstone.

From **Swanley** to Maidstone we pass through cuttings and tunnels in the Chalk to the Dart Valley, past Eynsford and Shoreham, where to the west, on a spur of the fine hills, was the residence of Sir Joseph Prestwich. We pass through Lower Chalk and Chalk marl at Otford Junction, and thence on to the low ground of Gault, where the clay is worked for brick-making. Leaving Kemsing we cross on to the Lower Greensand at Ightham, a district made famous by Benjamin Harrison, whose researches on the Eolithic implements are well known Thence by Wrotham we pass sections of pale and ferruginous false-bedded Folkestone sands, and note brickyards in drift at West Malling. Here and onwards we may observe many orchards and hop grounds, with Ost Houses. Near Barming there is a fine view of the Medway Valley and of the gorge in the Chalk, north of Halling. Thence we pass through cuttings in the Kentish Rag to **Maidstone.**

London to Port Victoria.

We leave the main line at Hither Green and traverse a tract of valley gravel, brickearth, and London clay on to the Blackheath and Woolwich beds at Mottingham and **Eltham.** Thence we cross London clay to Sidcup, through a more rural district, mainly of Blackheath pebble-beds, with still some hop grounds; although here as elsewhere near London the builder is busy. We enter the Cray Valley near Bexley and further on pass Crayford, a noted locality for Pleistocene fossils, obtained from the brickearth, which is there largely worked. We cross the Dart Valley at **Dartford,** and proceed near a large ballast pit, where gravel is seen resting on the Chalk. Then we continue on Chalk through **Greenhithe** and further on pass near Galley Hill, where the gravel has yielded palæolithic implements and parts of a human skeleton, described by Mr. E. T. Newton.

On the route to **Northfleet** we note old Chalk pits and lime works, and we pass through Chalk cuttings on to **Gravesend.** Beyond we traverse an alluvial flat on to the Thanet and Reading Beds at Cliffe, with sand and ballast pits. Thence we proceed over a gently undulating country of London clay on to alluvial ground. This separates the mainland from the Isle of Grain, a tract of London clay capped by gravel, and bordered by alluvium on which **Port Victoria** is situated.

GEOLOGICAL STRUCTURE OF IRELAND.

In geological structure Ireland is intimately connected with Great Britain. The distance across the North Channel from Fair Head, in Antrim, to the Mull of Kintyre is but 15 statute miles; that from Donaghadee to Port Patrick 21, from Larne to Port Patrick 28, and to Stranraer 39 miles. The voyage from Dublin to Holyhead across the Irish Sea is reckoned at 70, and that from Kingstown at 64 miles, while the new route from Rosslare to Fishguard is 62. Across this interval the depth of water exceeds 50 fathoms in an almost continuous belt through the central parts of the North Channel, Irish Sea and St. George's Channel: it is less on the borders of the lands. Projects have been considered for connecting Great Britain and Ireland by a tunnel beneath the North Channel, and it is by no means improbable that a satisfactory submarine link could be made through the older Palæozoic rocks, with possible overlying Trias, if such a costly undertaking were justified.

From north to south the extreme length of Ireland is 302 miles; its greatest breadth 174 miles; and its area 31,591 square miles.

Ireland presents considerable diversity of feature. Its coast line, more indented than that of England and Wales, measures about 2200 miles, including great bays or sea-loughs, and affording many natural harbours. Cliffs border a great part of the coast, and some of exceptional grandeur rise nearly 2000 feet into adjacent mountainous ground. Moreover, inland there are countless sheets of water, many small, but some of large extent—in all occupying an area equal to nearly 1000 square miles. There is not, however, the same variety of geological formation, nor such a regular succession in the arrangement of the strata, as in England. We miss the stonebrash hills and clay vales, the chalk downs and sandy uplands, of Central and South-eastern England.

The very oldest rocks, met with in the north-west, form continuations of the Central Highland schists or Dalradian of Scotland. In the Ordovician and Silurian belts that extend from Down to Cavan and Louth, we recognize a continuation of the Southern Uplands of the same country; rocks in both areas, likewise in Dublin and Wicklow, penetrated by mountainous masses of granite. Again in the great basaltic plateau of Antrim we find an isolated portion of the volcanic regions of Mull, Staffa, and Skye.

A very large part of Ireland, that known as the Central Plain, is in point of structure a huge irregular basin or saucer of Carboniferous Limestone, comparable in the nature of its strata with that region of moorland and dale that in England extends from Berwick through West Yorkshire to Ashbourne in Derbyshire. While in place of the Pennine Chain these rocks have for the most part been worn down to a monotonous level, and extensively covered with Drift and Peat; yet on its borders the Carboniferous limestone, which is indeed the chief foundation-rock of Ireland, presents features akin to those of England, in the mountainous tracts of north Sligo, and the elevated coal-fields of Arigna and Kilkenny.

In the south, again, the mountainous tracts and uplands of Kerry, Cork, and Waterford are formed largely of Old Red sandstone or Devonian rocks, comparable with those of Pembrokeshire and North Devon. (See Fig. 18.)

Thus in the main features of Ireland we have the great plain of Ireland seldom rising above 300 feet, encircled and locally diversified by mountainous or hilly ground; the wider tracts of low land extending between Dublin and Galway, in the upper drainage areas of the Boyne, the Barrow, and the Shannon.

In the long course of its geological history Ireland has been subject to many uplifts and depressions, and to widespread erosion. Both mountainous grounds and lowlands are formed of rocks of all ages. A complex of ancient schists and quartzites, with granite intrusions, together with Ordovician and Silurian rocks, form the more varied mountain scenery in Galway, Mayo, Donegal, and Tyrone. Ordovician rocks, again with great intruded masses of granite, form the lovely mountains of southern Dublin and Wicklow. The Old Red sandstone rises up in the noble heights of Kerry and western Cork, including Ireland's highest mountain of Carrantuohill (3414 feet) in McGillicuddy's Reeks. (Fig. 18). The Carboniferous rocks rise in mountainous form, notably on the borders of Sligo, Leitrim, Cavan, and Fermanagh (Fig. 19). The Secondary strata play a limited and comparatively unimportant part in the scenery; but the igneous rocks of Tertiary age form the bold mountains of Mourne, the great plateau and the dark precipices of Antrim and Londonderry, with the famous Giant's Causeway.

A great part of the country, formed of disturbed Archæan and Cambrian rocks, was eroded and covered by Ordovician, Silurian, Old Red Sandstone, and Carboniferous strata; and after the close of the Carboniferous era the rocks were again folded and upraised, while immense denudation took place prior to the succeeding deposits. Unfortunately the greater portions of the Irish coal-measures were swept away, and the remnants where productive are limited in area, and elsewhere of little economic importance. Hence there has been no justification for deep experimental borings in search of coal, such as have been made in various parts of England.

This paucity of coal has restricted the manufacturing industries. Nor are the metalliferous deposits that occur in Wicklow and Wexford a source of considerable wealth. With building and ornamental stones Ireland, however, is well supplied.

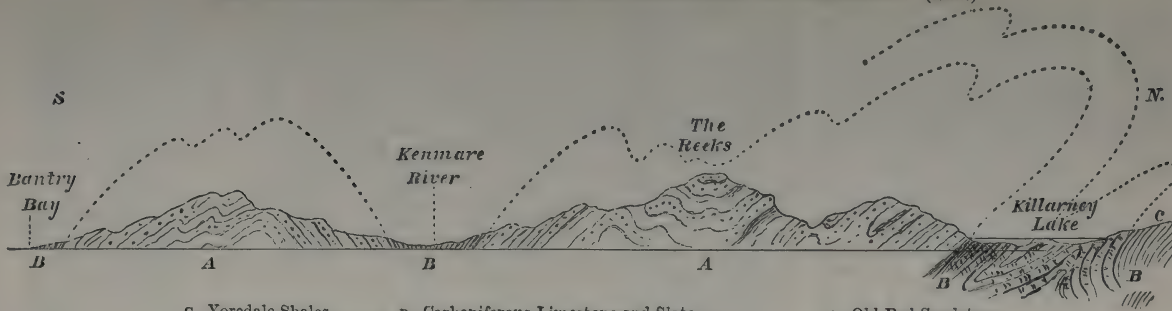
The Secondary strata that extended over the north-east of Ireland introduced some useful materials, rock-salt and gypsum, to say nothing of the Chalk which supplies lime and whiting.

The eruption of the lavas in Tertiary times likewise left products of economic value, in the bauxite utilized in the manufacture of aluminium, as well as in sundry iron-ores and ochres.

Of later accumulations those of the Pleistocene period were of great importance, from an agricultural point of view. During the Ice Age the land may have been connected with Great Britain, but, if so, at the close of the period the intimate and finally icy bond was severed.

The extensive erosion of the country, and the dissolution as well as mechanical abrasion of the large Limestone areas in the formation of the Central Plain, have left a tract of ill-drained low land with many areas of bog and lake. Lough Neagh, the largest lake, is considered to be due in part, at any rate, to subsidence of the area caused by the outpouring of so much volcanic matter in Tertiary times.

FIG. 18.—SECTION ACROSS THE LAKES AND MOUNTAINS OF KILLARNEY. (*Hull.*)



C Yoredale Shales. B. Carboniferous Limestone and Slate. A. Old Red Sandstone.

The dotted lines show the approximate extent of the strata when folded, prior to denudation.

FIG 19.—SECTION THROUGH CUILCAGH AND THE "MARBLE ARCH," FLORENCE COURT, ENISKILLEN. (*Hull.*)

1. Millstone Grit. 2. Yoredale Beds. 3. Upper Limestone. 4. Middle Limestone (Calp).

The dark band between *a* and *b* (Marble Arch) shows the position of the underground channel.

The results of the cold Pleistocene period were to distribute over the greater part of the country debris that has served to produce rich soils, and to render fertile some regions that would otherwise have been rocky and barren.

The soil primarily due to the decomposition of the substrata, whether Glacial Drift or more solid and uniform rock-formation, varies a great deal in the sense of being gravelly, loamy or peaty. Owing to the extensive coverings of Drift and the large areas of subjacent Carboniferous limestone, there is more uniformity in the soil, despite its mixed and stony nature, than is the case in England. There in some of the Midland and in most of the Southern Counties fairly distinctive soils are found on the broad outcrops of various formations. Thus we miss in Ireland the vales of stiff and heavy clay that characterize the chief dairy-lands in England, just as we miss the distinctive tracts of brashy upland, or of chalky boulder clay. In Ireland, however, the Drift containing *debris* of Carboniferous limestone, extends far and wide, and gives rise to fertile lands. The large tracts of Basalt also enrich the soil directly or indirectly.

Arthur Young in his journeys across Ireland (1776-79) remarked that the land was more cultivated than in England. It is now estimated that about three-quarters is under cultivation apart from woods and plantations—and of this more than half the country is under grass (pasture) and about one-tenth under meadow and clover.

That so large an area is under grass is due more to the climate than to the soil. It is a country of pasture-land, and even on the mountainous grounds there is more of grass, and less of heather, than in Great Britain, so that the name of Emerald Isle is as appropriate in Connemara, as in the rich pastures of Leinster. Oats are grown in most counties; barley and rye chiefly in the south and south-east of Ireland.

In fine weather during the early summer when the hawthorn is in bloom, the country looks a picture of agricultural wealth, but when we remember that the entire population is rather less than that of the Metropolis of London, we are not surprised when we look in vain in many parts for the labourer and the homestead. The population is estimated at 140 per square mile.

FORMATIONS OF IRELAND.

SEDIMENTARY AND METAMORPHIC ROCKS.

		Thicknesses in feet.
RECENT or HOLOCENE	Alluvium with peat and marl, Blown Sand, Estuarine and Marine beds (Raised Beaches): of Neolithic and later ages	
PLEISTOCENE	River Gravel	
	Glacial Drift	up to 100
EOCENE ?	Lough Neagh Beds	250
UPPER CRETACEOUS	Chalk; Hibernian Greensand	80 to 300
JURASSIC	Lower Lias	50 to 60
TRIASSIC	Rhætic Beds	50
	Red Marl and Sandstone (Keuper)	1100
	Red Sandstone (Bunter)	900
PERMIAN	Magnesian Limestone, Breccia, and Conglomerate	about 20
CARBONIFEROUS	Coal-measures	1500 to 2000
	Millstone Grit	150 to 500
	Carboniferous Limestone Series	up to 6000
DEVONIAN	Upper Old Red Sandstone	3000 to 4000
	Lower Old Red Sandstone and Dingle Beds	3000 to 10,000

		Thicknesses in feet.
SILURIAN	Ludlow Series Wenlock Series May Hill or Llandovery Series	
ORDOVICIAN	Bala and Caradoc Series Llandeilo Beds	
CAMBRIAN	Bray Head Beds	4000
ARCHÆAN	Schists and gneiss, quartzite and limestone	

IGNEOUS ROCKS.

Acid. Granite, Quartz-porphyry, Felsite, Pitchstone, and Rhyolite
Intermediate. Diorite, Andesite
Basic. Gabbro, Diabase, Dolerite, Basalt
Ultra-Basic. Serpentine

[N.B.—With reference to the grouping, see notes p. 14.]

G. Granite.

Granite, more or less sheared, occurs in Donegal, Tyrone, Mayo, and Galway; and in the Barnesmore tract in Donegal there are dykes of Pitchstone.

The Granite at Newry, and Crossdoney near Cavan, is intrusive into Silurian and Ordovician; in Wicklow and Dublin it has invaded the Ordovician rocks, but is of older date than the Carboniferous. In the Mourne Mountains and at Carlingford the granite (or granophyre) is of Tertiary age, intruded during the earlier phases of igneous activity, of which the rhyolites of Tardree, in Antrim, as Prof. Cole points out, were surface manifestations.

V. Andesites, &c.

Andesites occur in Meath, Tyrone, and in Lambay Island.

Quartz-porphyries and felsites, and occasionally rhyolites, appear among the Silurian, Ordovician and older rocks, in Wicklow, Wexford, Waterford, Kerry, Galway, Mayo, and Roscommon.

T. Basalt, Greenstone, &c.

Diorites occur in Wicklow, Galway, and Sligo.

Gabbro is found in Wicklow, and more prominently among the Tertiary igneous rocks in Armagh and Louth. Dolerite appears in Meath, Down, Mayo.

Basalt covers great part of Antrim, and there are numerous intrusive masses near Limerick and in many other localities.

S. Serpentine occurs in Galway, Mayo, and Sligo.

SEDIMENTARY AND METAMORPHIC ROCKS.

27. Archæan and Metamorphic.

This comprises a complex group of unfossiliferous crystalline rocks, schists of various kinds and quartzites, together with bands of altered limestone—invaded by granite and other igneous masses. They form mountainous ground in N.W. Ireland, in Donegal, Londonderry and Tyrone, in the Ox Mountains of Sligo, and in the western parts of Mayo and Galway.

26. Cambrian.

The Cambrian rocks (Bray Head series) consist of green and purple grits, quartzites, slates, shales, and rarely limestone; there are no distinctive fossils, but some obscure organic remains, mostly attributed to tracks and burrows of worms, have been found: such as *Arenicolites*, *Histioderma*, and *Oldhamia*. The rocks occur at Howth, at Bray Head and in the country further south, also in the south-west of Wexford.

Localities for fossils: Howth, Bray Head, Greystones, Cahore.

25. Ordovician. Fossils: Plate 35.

Representatives of Llandeilo and Bala beds are met with in several areas; but there is no evidence of Arenig rocks nor of any conformity with the Cambrian. The rocks consist of grey and green sandstones, grits and conglomerates, slates and shales, with occasional limestones, and contemporaneous volcanic rocks. They contain many graptolites, corals, crinoids, trilobites, brachiopods, and other fossils. They extend in a belt, interrupted in places, from Bangor to near Monaghan and Cavan; they appear in Tyrone near Pomeroy; in southern Mayo (Doolough beds); in Galway, south-west of Loughrea; here and there on the eastern coast, in Louth and Meath, and along the borders of the Wicklow Mountains; and they occur in the counties of Wexford and Waterford.

Localities for fossils: Ballygrot and Carnalea near Bangor, Desertcreat near Pomeroy and Tirnaskea (Tyrone), Six mile bridge (Slieve Bernagh), Chair of Kildare, Portraine near Dublin, Ballymoney and Enniscorthy (Wexford), Newtown Head, Tramore (Waterford).

24. Silurian. Fossils: Plate 36.

These rocks, equivalent to the Llandovery, Wenlock and Ludlow groups, consist of sandstones, quartzite, conglomerates, and greenish slates, with some beds of limestone; and they yield graptolites, corals, trilobites, brachiopods, mollusca, &c. They occupy a broad area in Down, Louth, and the southern parts of Armagh and Monaghan, and they extend into Meath. According to Mr. G. H. Kinahan, in Mayo on the borders of Killary Harbour, the Owenduff or Gowlaun series belongs to the Llandovery division, the Mweelrea beds to the Wenlock division, and the Salrock beds to the Ludlow division. In the south-west fossils of Llandovery age have been met with in the Silvermine and Slieve Felim Mountains. Again, in the Dingle promontory, in the beds of Anascaul, Ferriter's Cove and Croaghmarhin, the three Silurian divisions are represented, and many fossils have been obtained: evidences also of contemporary volcanic action occur in this district.

Localities for fossils: Tullygarvan (Down), Desertcreat near Pomeroy, Lisbellaw (Fermanagh), Mweelrea (Mayo), Ferriter's Cove and Smerwick, Dingle.

23. Old Red Sandstone and Dingle Beds. Fossils: Plate 37.

The Old Red sandstone of Ireland comprises a lower division which rests conformably on the Silurian; and an upper division, known as the Yellow sandstone, which in south-west Ireland appears to rest unconformably on the lower division, as well as on Silurian and older rocks, and is conformably overlain by the Carboniferous rocks. In western

Kerry and Cork the lower division is from 3000 to 10,000 feet thick, including in the Dingle promontory, in the mountains near Killarney and at Glengariff, a great series of grits (Dingle beds and Glengariff grits), together with slaty rocks, red sandstones, conglomerates, and beds of cornstone. The Dingle beds and Glengariff grits have been grouped with the Silurian by some authorities. Remains of plants have been obtained from the Dingle beds, and remains of fishes have been found in the strata grouped as Lower Old Red sandstone.

The Upper Old Red sandstone consists of yellow and brown sandstones, with beds of conglomerate. Its thickness is 3000 to 4000 feet in Kerry; and the conglomerate of Inch on Dingle Bay, south-west of Slieve Mish, is a prominent bed in that area.

Near Cork and in Co. Waterford, the Upper and Lower Old Red sandstone appear to be conformable, and they form hilly and mountainous ground.

The freshwater mollusc *Archanodon Jukesi* occurs in the Upper or Yellow sandstone (the Kiltorcan beds of Kilkenny), and remains of fishes, crustacea and plants also occur.

Various tracts of Old Red sandstone appear on the borders of the Ordovician areas in Tipperary, Clare and southern Galway, and on the borders of King's and Queen's Counties. Further north, and also south-west of Wexford, there are grits and conglomerates (mostly at the base of the Carboniferous series), that are grouped with the Old Red sandstone.

Tracts of these rocks also occur north of Newport in Mayo, in the Curlew Mountains, at Fintona; and smaller areas appear in the Chair of Kildare, at Pomeroy, and at Cushendall on the Antrim coast.

Locality for fossils: Kiltorcan, Kilkenny.

22 and 21. Carboniferous Limestone Series. Fossils: Plate 38.

This great series is divided into several groups that may be locally separated, but in mass it is variable, and the sub-divisions cannot always be determined. They are as follows:—

Upper Carboniferous Limestone.
Middle Carboniferous Limestone or Calp.
Lower Carboniferous Limestone.
Basement Beds.—Lower Carboniferous Sandstone, Lower Limestone Shale and Conglomerate, Carboniferous Slate and Coomhola Grit.

The *Basement Beds* are probably the most variable in character and thickness. In the north they approximate to the Calciferous sandstone series of Scotland, comprising at Fair Head sandstones and limestones with seams of coal and ironstone in the Ballycastle coal-field of Antrim. Elsewhere in north Ireland they are largely composed of conglomerates, as well as sandstones and shales, attaining thicknesses of 1000 feet in north Mayo, and 2000 feet in Donegal. Some of the beds have been grouped with the Upper Old Red sandstone.

The Lower Limestone shales, which occur in Wexford and on the coast near Malahide in Co. Dublin, comprise conglomeratic beds and overlying shales with bands of limestone, altogether not exceeding 200 feet.

A varied assemblage is met with in Co. Clare, of shales, flags, grits, and sandstones with occasional limestones; while in the south of Ireland, eastwards from the river Coomhola, near Bantry, there is a vast thickness of Carboniferous slate and Coomhola grits, which form parts of an interbedded series, as much as 6000 feet thick in places, that extends even into the horizon of the Carboniferous limestone: the slate replacing it to a certain extent, as pointed out by Jukes. He also noted the rock-characters and fossils which appear to connect the Carboniferous slate of Ireland with the Marwood and Pilton Beds of north Devon.

The *Lower Carboniferous Limestone*, for the most part a grey limestone, is in places shaly and sandy, oolitic and dolomitic, and it occasionally contains chert. In thickness about 600 feet in Donegal and Mayo, it expands elsewhere to about 2000 feet, occupying much of the Central Plain.

The *Middle Carboniferous Limestone* is a dark earthy or shaly limestone (provincially termed "Calp"). It includes calcareous shale, with beds of purer limestone, occasional dolomite, and chert, and sometimes, as in Sligo, considerable masses of sandstone. In that county and in Fermanagh, the division attains a thickness of 1000 feet, while in the east and south-east of Ireland the thickness is about 600 feet. Interbedded volcanic rocks occur in south-east Limerick.

The *Upper Carboniferous Limestone*, in mass a grey limestone, also contains shaly limestone like calp, shale and chert, and occasionally sandstone and conglomerate. In places it is dolomitic and oolitic. In the north of Ireland its thickness varies from 700 to 1000 feet; it forms mountainous ground in Sligo, and has been hollowed out in many inland caves. To the south the thickness in places is as much as 1500 feet. The Burren Limestone in the Burren district of Clare is remarkably fissured and weathered, and the rocks which extend along the north-west coast form part of the great cliffs of Moher. Good building-stone and marble have been obtained in many localities.

Localities for fossils: Bundoran (Donegal), Tyrone, Armagh, Enniskillen, Castleknock, Clondalkin and St. Doolagh's (Dublin), Kildare, Galway, Lisdoonvarna (Clare), Hook Head (Wexford), Dungarvan (Waterford), Mitchelstown, Queenstown and Old Head of Kinsale (Cork), etc. etc. Everywhere in this series of rocks fossils may be found.

The *Yoredale Rocks* consists of a great series of black shales, sandstones, flagstones, and grits, with thin limestones, clay ironstone, and impure coaly seams. The thickness in the north and east of Ireland is from 300 to 600 feet; and in the north the upper part is in the main a shale series, underlain by sandstones and grits that yield good building-stone. In the south-west the thickness is estimated at from 800 to 3000 feet, but there is often a difficulty in separating the beds from the Millstone grit. In the neighbourhood of Ballinhassig, Cork, there are beds of dark shale, white clay, chert-beds, &c., that may be compared with the Lower Culm-measures of Devon, and in them the mineral wavellite is also met with. *Goniatites*, *Posidonomya Becheri*, and other fossils occur in the strata. Dr. Wheelton Hind recognizes the representatives of the Pendleside series in counties Clare and Limerick. Much remains to be done in defining the palæontological divisions in the Lower and Upper Carboniferous strata.

20. Millstone Grit. Fossils: Plate 38.

This group consists of quartzose grit, sandstones and flags, with shales and occasional beds of workable coal, as in Arigna. It is essentially a flagstone series, varying in thickness from 150 or 200 feet in the north, to about 500 feet in the south-east of Ireland.

19. Coal Measures. Fossils: Plate 38.

This formation comprises a series of grits, sandstones, and shales, with fire-clays, ironstones, and coal, and is from 1500 to 2000 feet thick. It is regarded as including representatives of the Lower (or Gannister) series, with occasional marine beds; and of the Middle series of England and Wales. Workable seams of coal occur locally in both lower and upper divisions.

Southern Coal-fields.—Although "Coal-measures" occur over extensive tracts in counties Clare, Kerry, Limerick, and Cork, the strata in this Munster coal-field are much disturbed, and the seams for the most part poor. Coal has been worked more particularly in the tract west of Mallow. More important is the Leinster coal-field, including the Castlecomer coal-basin, which occupies parts of Kilkenny, Queen's Co., and Carlow, and an outlying tract in Tipperary. The coal in this southern area is anthracitic. (See Fig. 20, p. 155.)

In Leinster there is also a small belt of Coal-measures with a seam of bituminous coal, to the south of Carrickmacross, on the borders of Monaghan and Meath. Geologically, this belongs rather to the Northern coal-fields.

Northern Coal-fields.—Although small in area, these tracts of Coal-measures yield good bituminous or household coal. They include the mountainous Leitrim or Arigna coal-fields of Connaught; and that of Tyrone at Coalisland near Dungannon, in some respects the most important of the Irish coal-fields.

It was reckoned by Prof. Hull, for the Royal Commission on Coal Supplies, 1905, that about 174 million tons of coal are available for the supply of future years. The amount annually raised is about 100,000 tons.

Localities for fossils: The coal-fields generally, and that of Jarrow (Kilkenny) in particular.

17 and 18. Permian. Fossils: Plate 39.

Thin beds of Magnesian Limestone with characteristic fossils occur at Tullyconnel near Ardtrea, and at Cultra north-east of Holywood. Near Armagh there is a small outlier of sandstone, breccia and conglomerate, less than 20 feet thick, and regarded as of Permian age.

Localities for fossils: Tullyconnel, Tyrone; Cultra, Down.

16. Lower Trias: Bunter.

Beds of soft red or yellow and mottled sandstone, with marly beds and gypsum, occur near Kingscourt in Cavan, and in adjacent parts of Monaghan and Meath. Similar beds of sandstone, often ripple-marked, are met with on the southern borders of the great basalt plateau of Antrim and Londonderry, near Belfast, Dungannon, &c. The thickness of the Bunter has been estimated at 900 feet.

15. Upper Trias: Rhætic Beds, Keuper Marls and Sandstone. Fossils: Plate 39.

Keuper Sandstones, comprising white and brown sandstones and pebbly sands, form a basement to the great mass of Keuper Marls, reckoned to be 750 or 800 feet thick, near Belfast. The marls contain gypsum at Cushendall, and important beds of rock-salt at Duncrue near Carrickfergus. The full thickness of the Keuper has been estimated at 1100 feet. The strata overlap the Bunter beds in northern Londonderry and elsewhere.

At Rhone Hill, near Dungannon, Tyrone, the Triassic fish *Dictyopyge catopterus* was obtained.

The Rhætic Beds rest on the grey or blue marls which form a passage between them and the Keuper. The full thickness of the strata is about 50 feet. The upper part, grouped as White Lias, is represented in the Belfast and Larne area by thin white limestone, grey and red marls, and arenaceous shales about 25 feet thick. The grey marls at Waterloo, near Larne, contain curious oolitic structures. The beds below comprise about 20 feet of black shales, with thin sandstones and limestones.

The strata (since termed Rhætic) were described in 1843 by J. E. Portlock, who observed the shales and bone-bed with fish-remains in the scarp between Magilligan and Keady to the east of Limavady, and he then named and figured the characteristic *Avicula contorta*. The strata here, as in the Belfast country, occur beneath coverings of Basalt and Cretaceous rocks, and in some localities of Lower Lias.

Localities for fossils: Lisnagrib (Londonderry), Colin Glen and Cave Hill, near Belfast, Woodburn, Whitehead, Larne, and Garron Point (Antrim).

14. Lower Lias. Fossils ; Plate 40.

Strata representing the zones of *Ammonites planorbis* to *A. Bucklandi*, and consisting of clays, marls, and more or less shelly limestones, are met with above the Rhætic Beds, and below the Cretaceous rocks and the great Basalt plateau in Antrim and Londonderry. At Portrush, where the common Ammonite is *A. Johnstoni*, the shales have been much altered by the basalt. The full thickness of the formation is nowhere seen at one locality, but probably the Lower Lias is represented by 50 or 60 feet of strata.

The Middle and Upper Lias are not represented *in situ*, but fossils belonging to the formations have been recorded from Glacial Drift.

Localities for fossils: Colin Glen, Whitehead, Larne, Island Magee, Glenarm and Ballintoy (Antrim) ; Portrush (Londonderry).

6 and 7. Chalk and Hibernian Greensand. Fossils: Plates 44 and 45.

The Upper Cretaceous Rocks include representatives in time of Gault and Upper Greensand, as well as Chalk ; but the Hibernian Greensand, as pointed out by Dr. W. F. Hume and others, includes marginal deposits of the age of the Lower and Middle Chalk of England. This Greensand comprises green and yellow glauconitic sands and sandstone, with beds of grey marl, and chert. The sands weather to a red colour in places. A pebbly and nodular phosphatic layer occurs at the base. The thickness varies from about 10 feet near Larne to 80 feet near Belfast.

The Chalk, which represents the Upper Chalk of England, is for the most part a hard and compact white limestone, with nodules and tabular layers of flint, and occasionally with the large masses termed paramoudras. The lower part is glauconitic. Near Cushendall, where the Chalk rests directly on the Triassic Sandstone, there is a conglomerate at its base ; while in the Moira district the local base of the Chalk is a glauconitic limestone with grains of quartz, known as the "Mulatto Stone." The

Chalk is thickest on the northern coast of Antrim, where as much as 112 feet is present.

Localities for fossils: Moira, Kilcorig, Colin Glen, Woodburn, Island Magee, Larne, Ballygalley Head, Ballycastle, Rathlin Island, near Portrush, and Limavady.

4. Eocene.

The Lough Neagh beds which occur on the southern borders of Lough Neagh in the counties of Tyrone, Armagh and Antrim, are much concealed by thick drift and alluvial deposits.

The beds consist of white pipe-clay and purplish clays and sands, with occasional beds of lignite and nodules of clay-ironstone: having a thickness of upwards of 250 feet. The clays have been utilised for pottery. Fossil plants, including silicified wood, occur in the strata. They were formerly classed as Pliocene, but are regarded as of Eocene age by Mr. J. Starkie Gardner.

Plant-beds associated with the basalt were found in a cutting of the railway between Templepatrick and Dough. Plastic clays and sands with lignite also occur near Caher, in Co. Tipperary.

1. Recent and Pleistocene. Fossils: Plate 50.

The more "solid" strata over the greater part of Ireland, especially in the eastern and central portions, are extensively covered with Glacial Drifts and peat-bogs. The higher grounds of Donegal and Galway, of Kerry, Cork, Wicklow, and other mountainous regions, though mostly glaciated, are freer from Glacial Drift, but much peat-covered.

The Boulder Clay varies in thickness up to 100 feet and more, and naturally varies in composition. Over the central plain the included stones and boulders are mostly limestone, elsewhere this limestone-drift passes into a more mixed accumulation with a preponderance of siliceous and other stones. Mounds or ridges of Boulder Clay known as Drumlins, occur in elevations up to 100 feet or more, in straight and sometimes parallel lines. Gravels and sands occur over considerable areas and some of them, with marine shells, are found at elevations up to 1000 or 1400 feet. Shelly sands and gravels also occur beneath Boulder Clay on the lower grounds of Wexford, where from their use in agriculture they are known as the "Manure Gravels," and they contain some species characteristic of Pliocene. The organic remains in some of these shell-bearing gravels have been held to indicate great submergence; on the other hand, it has been remarked that while the shell-bearing gravels occur at all levels, they exhibit no material change in the character of the species, and that they were probably derived from the bed of the Irish Sea, by land-ice, during the period of maximum glaciation.

Maxwell H. Close, the pioneer in the Glacial Geology of Ireland, was of opinion that the country was glaciated by ice of great thickness, and little dependent on the mountains as sources of supply. During this period, as since advocated by Mr. Lamplugh, the Irish Sea basin was filled with ice (West British ice-sheet) which moved outward across the land; while Ireland itself formed an independent centre of glaciation, the Ivernian ice-sheet radiating from the region of Fermanagh. The direction of movement of the ice-sheets was modified to some extent by the configuration of the ground and by the local ice of those mountains which rose above the level of the ice-plateau.

The abundant Eskers which in the shape of "Green Hills" are scattered over the Central Plain and in the mountain valleys, are regarded by Prof. W. J. Sollas as marking the courses of streams beneath the ice-sheet, originating, perhaps, in many instances during the recession of the ice. They are formed of water-rolled gravel and sand, whereas the Drumlins appear to consist of Boulder clay deposited by the ice itself, and not much affected by water action. Sheets of flood-gravel followed the melting away of the ice-sheets, and during this period it has been shown of late years that certain dry gaps, like the Scalp and Glen of the Downs, may be "overflow channels" from lakes on the margin of the melting ice-sheet, or from streams directly resulting from the melting, and these being of a torrential nature, excavated the remarkable features.

The land which had been upraised above its present level, was depressed after the period of glaciation, and then the Raised Beaches which are of Neolithic age, and certain Estuarine beds, such as occur at the heads of Belfast and Strangford Loughs, and at Clontarf, near Dublin, were formed.

Subsequent elevation of 10 or 15 feet brought the land to its present level; and when the strata are comparatively soft and easily eroded there is considerable loss of land, as near Killiney, where the waste is estimated at 2 feet per annum. On the Antrim coast, near Glenarm, numerous landslips have taken place, where the Basalt and Cretaceous strata form a scarp above the Lias clays, &c.

It is reckoned that there are more than one million acres of turf bog in Ireland; and these great areas are due in part to the absence of good natural drainage in the Central Plain.

The Bog of Allen, said to occupy about 240,000 acres in western Kildare, King's County, and southern West Meath, is in general about 250 feet above sea level, and formed by a number of isolated tracts of peaty ground. Large areas of bog-land occur in Donegal, Mayo and Galway.

Peat is usually divided into the Lowland or Red Bogs, and the Mountain or Black Bogs, which, containing more woody matter, are regarded as more valuable. By various stages these pass one into the other, the formation of peat having taken place at all levels and in various situations, even on isolated hills and spurs. The lower peat bogs are formed mainly of *Hypnum*, rushes and sedges; the higher of *Sphagnum* and heather. The average thickness of the peat is 25 feet, but it is sometimes as much as 50 feet in depth. Dr. T. Johnson has expressed the opinion that some bogs increase 5 or 6 inches in a year: some not at all.

Bog clay has been used for brickmaking, and bog iron-ore occurs in places.

Mountain bogs have become in many instances "Moving bogs." When based on clay they are subject to slip away towards lower grounds, especially when a period of dry weather is followed by continued heavy rain. Bogslides or bogbursts may then cause disaster to villages, as has been the case notably in counties Mayo and Kerry.

Numerous remains of Irish Elk (*Megaceros Hibernicus* or *Cervus giganteus*) have been obtained from marl or clay at the base of peat-bogs, in Counties Limerick, Galway, Dublin, Wexford, &c. Mr. Clement Reid describes the "Megaceros-marl" as due largely to decayed remains of the calcareous plant *Chara*, and he would thus account for the entombing of so many remains of the animal:—

"Those familiar with pools containing *Chara* will be well aware of the appearance of shallowness, and of a solid floor, which is so deceptive.

The *Chara* and *Potamogeton* may grow from a depth of several feet, but they often appear to form a carpet of bright green turf a few inches under the surface of the clear water. Any animal treading on this turf would immediately plunge head-foremost into the water, and the wide-branching antlers of *Cervus megaceros* would become entangled amid the *Chara* stems, and still tougher Pondweeds, so that the animal would have scarcely a chance of escape."

Caves in the limestones districts have yielded remains of extinct mammalia, and of man; but while the mammoth has been found at Shandon, near Dungarvan, Co. Waterford, no remains of Palæolithic man have been obtained. The caves in Sligo, Fermanagh and Clare have yielded remains of Neolithic and later times.

Among the animals the bear appears to have become extinct before historic times, while the wolf was exterminated in the early part of the 18th century.

GEOLOGY OF THE COUNTIES OF IRELAND.

Antrim (Ulster). Map 34a. Area 751,965 acres.

Antrim is formed mainly of a great sheet of Tertiary basaltic rocks, upwards of 1000 feet thick in places; the remains of extensive lava-flows, often amygdaloidal, with sills of columnar basalt, and with intermediate beds of volcanic tuff, red ochreous clay (bole), pisolitic iron-ore, lignite, and plant-beds. These rocks, much concealed by drift and peat, extend from the river Bann on the west to the shores of Lough Neagh, to near Belfast and Larne, and northwards to Portrush and the Giant's Causeway. They spread over great part of Island Magee, and dominate the coast at Ballygalley Head, Garron Point, and the higher part of Fair Head or Benmore (639 feet). They occur also in the Maidens off Larne, in Rathlin Island, and in the Skerries off Portrush. Beneath this great volcanic plateau a varied series of strata is exposed, along the sea-borders and inland escarpments: they comprise Cretaceous rocks (Chalk and Hibernian greensand), which rest unconformably on Lower Lias, Rhætic beds, and New Red rocks.

Notable sections of the strata are to be seen in the bold scarps which extend along the north-west side of the Lagan Valley, at Cave Hill (1100 feet), north-west of Belfast, in Island Magee, at Larne, at Red Bay, at Kinbane or White Head, and elsewhere round the coast to Portrush; the Chalk being indurated by the basalt, and the Lower Lias shales with *Ammonites Johnstoni* being locally altered, as at Portrush, into a kind of lydian stone. Rock-salt is obtained from the New Red Marls near Carrickfergus, and the New Red sandstone is quarried for building stone near Larne and at Red Bay.

At Ballycastle Bay, near the grand cliff of Fair Head, coal has been worked in the Carboniferous Limestone series. Old Red sandstone appears on the northern side of Red Bay, and the uplands westwards and at Runabay Head are formed of metamorphic rocks.

Inland the Basalt plateau rises to 1817 feet at Troston, west of Red Bay. In that famous locality, which extends to the west of Bengore Head, the Giant's Causeway is an irregular pavement on the foreshore, formed of a sheet of columnar basalt. This, the lowest part of the Upper Basalt, rises to form the "Organ Pipes" in the cliffs to the east: producing, with other bands, marked features in the romantic scenery of these cliffs. The conspicuous prismatic columns with their "ball and socket" structure, have been formed by the cooling and shrinkage of the molten lava.

The Lough Neagh beds, which are regarded as of Eocene age, occur along the south-eastern borders of Lough Neagh. This Lough, the largest British lake, occupies an area of 98,000 acres, and belongs in part to Londonderry, Tyrone and Armagh, but mainly to Antrim.

The raised beach, well seen at Larne, is of special interest from the Neolithic implements found in it; these in the opinion of Mr. G. Coffey and Mr. R. L. Praeger give evidence that man was on the ground during the submergence which led to the formation of the beach, and that he continued (as Neolithic man) until after the movemont of elevation had set in. Blown sand occurs east of Portrush.

Sea-side resorts: Ballycastle, Cushendall, Cushendun, Glenarm, Larne (stony beach, sands and cliffs), Whitehead, Portrush (rocky shore, sands, cliffs).

Armagh (Ulster). Map 34a. Area 327,704 acres.

In this county we find a considerable variety of geological formations. Great part of the ground south of Armagh is occupied by Ordovician and Silurian rocks. To the west of Newry there is a great tract of granite, which is largely worked at the Bessbrook quarries. This granite, which has invaded the Silurian strata, has itself been penetrated by masses of granitic and other rocks of probably Tertiary age. Thus between Dundalk and Newry rises Slieve Gullion (1893 feet), formed largely of the variety of granite known as granophyre, with also gabbro, through which it has intruded. Armagh itself is based on Trias and Permian, that overlie a belt of Carboniferous limestone, which has yielded useful beds of marble. Further north there is a tract of Trias, and a mass of basalt at Portadown and Lurgan, beyond which the shore of Lough Neagh is bordered by drift-covered Eocene strata (Lough Neagh beds). The soil of Armagh in general is fertile, but there is a good deal of bog-land.

Carlow (Leinster). Map 34b. Area 221,473 acres.

Granite forms the foundation of the greater part of this county, much of it Drift-covered, low-lying or gently undulating: the higher grounds are on the borders of Wexford. There Ordovician rocks appear near Kildavan, and they are more or less altered in proximity to the granite. On the western side of the county, the town of Carlow is based on Carboniferous limestone, a belt of which extends along the valley of the Barrow to Bagenalstown. This rock supplies varieties of black marble. Further to the west, a portion of the Leinster coal-field enters the county. (See p. 155.)

Cavan (Ulster). Map 34a. Area 477,399 acres.

This is to a large extent a Drift-covered area, with numerous small loughs and bogs. In the north-west, the Upper Carboniferous rocks form mountainous ground rising to 1648 feet in Benbrack and 2188 feet in Cuilcagh. (See Fig. 19, p. 137.)

Upper Lough Macnean in the north is bordered by Carboniferous limestone, and the same rock forms the foundation from Swanlinbar (noted for a mineral spring), through Lough Oughter with its numerous islets and promontories, to Cavan. A tract of granite occurs at Crossdoney, south-west of Cavan, in the Ordovician rocks which border the Carboniferous limestone, while southwards and eastwards the foundation-rocks are chiefly Silurian.

A small area of Trias appears in the eastern portion of the county near Kingscourt; and bordering Lough Sheelin on the south is a fringe of Carboniferous limestone.

While for the most part an agricultural county, the soil is not regarded as especially fertile.

Clare (Munster). Map 34b. Area 852,389 acres.

This is a pastoral county, with a fine rocky coast. The western portion from the mouth of the Fergus, along the fertile shores of the Lower Shannon to Loop Head, northwards to Hag's Head, and eastwards to near Ennis, is much Drift-covered. The foundation-rocks are Upper Carboniferous; they yield flagstones, and include a small tract of Coal-measures with thin coals. The coast-line, with its caves and natural arches, and blow-holes, is remarkably fine; the cliffs of Moher, north of Hag's Head rising to upwards of 600 feet in the Carboniferous limestone and Yoredale rocks. Lough Donnell, south of Kilmurry, is hemmed in by a high bank of shingle. The northern part of the county, at Blackhead on Galway Bay, and the eastern parts, are formed of Carboniferous limestone, worked in places for marble, and covered with much Drift east of Ennis. At Edenvale, near that town, numerous caverns occur; while in the north, Lisdoonvarna is noted for its sulphur and chalybeate springs. Along the eastern borders the Old Red sandstone and Ordovician form large tracts of country around Lough Graney, and they extend in the Slieve Bernagh Mountains (1746 feet) to the borders of Lough Derg. Killaloe, on the Shannon, stands near the junction of the two formations.

Sea-side Resorts: Kilkee (sands and cliffs with caves), Lahinch (sands), Milltown Malbay near Spanish Point (sands), Ross near Loop Head (rocky coast).

Cork (Munster). Map 34b. Area 1,849,686 acres.

This, the largest of Irish counties, is a hilly and mountainous county, formed almost wholly of the Old Red sandstone and Carboniferous rocks, which range in belts across the county, with in general an E. N. E. and W. S. W. strike. A small tract of Ordovician appears in the Ballyhoura Mountains to the north-west of Mitchelstown.

The main features have been produced on a folded series of rocks; and the harder Old Red sandstone, with the Glengariff Grits, rises in central Cork, to the north of Macroom, in the Bochragh Mountains, to the west of which Caherbarnagh (2239 feet) forms a connecting link with the mountains of Killarney. Further south is the famous pass of Keimaneigh, in the Sheehy Mountains; while from the coast at Glengariff the rocks (Old Red sandstone) are prolonged westwards to the Caha Mountains and Slieve Miskish, north of Bear Haven, and to Dursey Island. They extend also from the east coast at Knockadoon Head through Queenstown, and the promontory west of Bantry, to Sheep Head, appearing again further south at Mizen Head, and at Cape Clear off Clear Island. On the east the Old Red sandstone forms bold cliffs at the entrance to Cork Harbour, at Crosshaven and Roches Point. The somewhat softer Carboniferous rocks have been eroded to form the Bays of Bantry and Dunmanus—great sea-loughs that owe their form in part to subaerial denudation prior to submergence. These rocks extend through Bandon and Clonakilty to Skibbereen. They comprise the Carboniferous slate and Coomhola grits, the former merging upwards and laterally into the Carboniferous limestone near Cork. The slate has been worked for roofing-material near Clonakilty and other places.

The rivers as pointed out by Jukes took their original courses from the uplands in a northerly and southerly direction, but their tributaries subsequently hollowed out courses along the softer strata in easterly and westerly directions, and partially in synclinal tracts.

Cork stands partly on the Carboniferous limestone, celebrated for the beds of marble known as "Cork reds"; worked near Cork and Midleton, and at Buttevant, north of Mallow.

Mallow, noted for chalybeate springs, and in particular for a warm spring with a temperature of 70° to 72°; and Fermoy, lower down on the Blackwater or "Irish Rhine," are situated on the borders of the Carboniferous limestone and Old Red sandstone. Mitchelstown, in the north-east of the county, is noted for dark and white marble. In the north-west are tracts of Coal-measures. (See also p. 143.)

Copper ores have been worked at Kilcrohane on Sheep Head. Hæmatite occurs on Bear Island.

A good deal of Boulder Drift is scattered over the country, especially in the eastern part, where the ground is more cultivated and there are tracts of dairy land, whence much of the Cork butter is produced. Peat is more prominent in the western parts. Of special interest is the occurrence of a pre-glacial raised beach beneath the Boulder Clay, on the borders of Cork Harbour, to which attention was called by Mr. H. B. Muff and Mr. W. B. Wright.

Some remarkable shell-heaps or "Kitchen-middens," formed largely of oyster-shells, occur on Brown Island and elsewhere on the coast bordering the Harbour.

Sea-side resorts: Ballycottin; Bantry; Aghada, Crosshaven, Glandore, Monkstown and Queenstown in Cork Harbour; Glengariff: Youghal (fine sands).

Donegal (Ulster). Map 34a. Area 1,197,153 acres.

Some of the oldest rocks in the British Isles extend over great part of this stony and mountainous county. They comprise various schists and slates, quartzites, occasional limestones that yield marble, extensive masses of granite and granitoid rocks, with large tracts of bogland on the uplands. The coast is much indented, and the cliffs are among the finest in Britain; Slieve League on the north of Donegal Bay, rising to nigh 2,000 feet. The old rocks occupy the promontory of Inishowen, which terminates in Malin Head, and they appear in the gap of Mamore; they extend over the larger region of north-west Donegal and adjacent islands, including Tory Island (granite and schist), and Aran Island (granite and quartzite). The fine conical peak of Mount Errigal (2466 feet) is formed of quartzite, and the Bluestack Mountains (2219 feet) of schists and granite. Granite has been worked at Gweebarra and Dungloe on the west coast, near Tamney on the borders of Mulroy Bay on the north, and at Barnesmore, north-east of Donegal. Around the shores of Donegal Bay there is a broad tract of the Carboniferous limestone series, with shales and sandstones as well as limestones.

These strata form Muckros Head, St. John's and Dooran Points on the north, and they are well seen in the cliffs and pavements of fossiliferous shaly limestone at Bundoran. They occur in the rocky valley of the Erne above Ballyshannon; and the sandstone has furnished a noteworthy freestone at Mountcharles. The bordering rocks on the north and east comprise a great thickness of basal sandstones and conglomerates, grouped sometimes with the Old Red sandstone. Small tracts of the Lower Carboniferous sandstone occur on the south-western shore of Lough Foyle.

Blown sands occur here and there in the bays, among the irregular rocky promontories, in Gweebarra and Inishfree bays, near Horn Head, in Sheep Haven and Pollan Bay; the more shelly sands have been used as manure. The agricultural districts lie mostly in the southern and south-eastern parts of the county, where there is much boulder clay and Drift sand and gravel. Donegal has a Spa with chalybeate and sulphurous waters.

Sea-side resorts: Buncrana on Lough Swilly (the "Lake of Shadows"), Bundoran (sands, rocks, cliffs), Dunfanaghy south of Horn Head, Killibegs, Moville on Lough Foyle, Portsalon on Lough Swilly (good beach, caves), Rosapenna east of Sheep Haven.

Down (Ulster). Map 34a. Area, 607,916 acres.

This pleasantly diversified county is largely composed of Silurian rocks, which form the promontory of Ards, extending from Donaghadee to Portaferry on the east of Strangford Lough. Belts of Ordovician rocks appear on the north and north-west at Bangor and near Lisburn. To the south the Silurian rocks, traversed by many igneous dykes, extend to Dundrum Bay and the borders of Carlingford Lough. In this latter region rise the Mourne Mountains, great masses of Tertiary granite, which in Slieve Donard attain a height of 2796 feet, and in Slieve Commedagh 2512 feet; the last-named celebrated for its "castles" or tors of weathered rock. Another, and much older granite tract extends north-westwards from Newry, and rises to 1755 feet at Slieve Croob, beneath which issue springs that form the source of the river Lagan.

At the Head of Strangford Lough at Scrabo and Dundonald, there is a tract of New Red rocks with intruded basalt; and these red rocks border the shores of Belfast Lough from Holywood, and extend along the Lagan valley above Lisburn, to near Moira. At Moira the Red rocks are covered by Cretaceous strata and overlaid by an extension of the basalt plateau of Antrim. At Cultra, north-east of Holywood, a small tract of Permian occurs: this includes magnesian limestone, with fossils, together with marls and conglomerate. It rests on Lower Carboniferous shales. A small mass of Carboniferous limestone occurs at Castle Espie, south-east of Comber at the head of Strangford Lough. At Moira, the Chalk, which contains large flints known as paramoudras, is burnt for lime and manufactured into whiting; the New Red sandstones are quarried for building purposes at Scrabo; the Newry granite is quarried at Castlewellan and other places; and dolerite at Rostrevor has been worked for paving-setts, tombstones, &c.

Drift deposits cover a considerable part of the county; and blown sand occurs in Dundrum Bay.

Ballynahinch is noted for a Spa, with chalybeate and sulphur wells.

Sea-side resorts: Ardglass, Bangor, Donaghadee, Dundrum, Holywood, Kilkal, Newcastle (sands), Rostrevor, Warrenpoint.

Dublin (Leinster). Maps 34a and 34b. Area, 218,873 acres.

Everyone who approaches Dublin for the first time by steamer, and in fine weather, will be impressed with the grand view of Dublin Bay, and the bordering land. Howth Head (Cambrian) stands out boldly on the north, with the islet known as Ireland's Eye (mostly Cambrian) beyond. Bray Head (Cambrian), just beyond the county boundary, stands out prominently on the south, backed by the great Sugarloaf and the granite mountains which extend from Killiney by Kingstown southwards into the Wicklow Range. The granite rises to 1479 feet in Three Rock Mountain, and to 1763 at Fairy Castle. To the south-east is the rocky gorge or "dry gap" known as "The Scalp," and to the east is "The Dingle," near Carrickmines, both cut through the granite (see p. 146). A belt of Ordovician rocks fringes the granite, both east and west. To the north through Rathmines and Dublin to Rush, the Carboniferous Limestone for the most part forms the foundation, with in places a basal conglomerate; and it is surmounted near Rush by so-called Yoredale beds and Millstone grit.

At Portraine, near Donabate, there is a tract of fossiliferous Bala Beds (limestones, grits and conglomerates, much disturbed), with associated andesites; and on Lambay Island there are tracts of Bala Beds, much andesite, and exposures of porphyrite ("Lambay porphyry"), intrusive in the andesite. Both Ordovician and Silurian rocks occur at Balbriggan. Great part of the country is flat, and drift covered, forming rich agricultural land. The drifts comprise boulder clay, shelly sands and gravels at various levels, together with esker-ridges. Raised beaches border Dublin Bay, and connect Howth with the mainland: they occur also at Balbriggan Bay. Blown sand also occurs at Portmarnock Point and elsewhere.

At Lucan there is a Spa, with sulphurous waters.

Sea-side resorts: Balbriggan, Blackrock, Clontarf and Dollymount, Dalkey, Howth, Killiney, Kingstown and Sandycove, Malahide, Merrion, Salthill (Monkstown), Sandymount, Skerries.

Fermanagh (Ulster). Map 34a. Area 437,360 acres.

This is largely a pastoral county, of Drift with many peaty areas, based on Carboniferous limestone. Upland and mountainous tracts of the same rock, overlain by Yoredale Rocks and Millstone Grit, occur in the eastern part, where Carnmore rises 1034 feet. On the south, Cuilcagh (capped by Millstone Grit) on the borders of Cavan, rises 2188 feet; and Belmore, to the north of Lower Lough Macnean, 1312 feet. The limestone forms much of the lower portion of the county, bordering Upper and Lower Lough Erne, the latter an exceptionally fine expanse of water, bordered by grassy and wooded slopes, and studded with grassy islands. Near Florence Court, the seat of the Earl of Enniskillen, the Limestone series rises into bold uplands, and the "Marble Arch" is a natural bridge of Limestone, through which the stream issues after an underground course. (See Fig. 19, p. 137.) At Lisbellaw there is a small tract of slates and conglomerates of Silurian and perhaps Ordovician age. East and north of Enniskillen there are tracts of Old Red sandstone, bordered by Lower Carboniferous sandstone, that extend to the shores of Upper Lough Erne; and there are ancient schistose rocks in the northernmost parts of the county bordering Tyrone, and also Donegal, not far from Belleek. This last-named place is famous for its iridescent porcelain, manufactured formerly from felspar, locally obtained, and now from imported rocks. The Lower Carboniferous sandstones yield good building-stone and flagstone.

Galway (Connaught). Maps 34a and 34b. Area 1,519,689 acres.

Essentially a mountainous county, Galway includes the grand scenery of Connemara. To the west of Galway town, Iar Connaught and the southern portion of the county is a veritable lake-land, a tract of granitic rocks, much glaciated, with drift and peat, and countless tiny loughs. Northwards at Recess and Clifden, we enter a region of schists, flaggy quartzites, occasional limestones, and sheared igneous rocks. The quartzites form the Maamturk Mountains with Letterbreckaun (2193 feet); and, westwards of Lough Inagh, Bunnabeola or the Twelve Pins, with Benbaun (2395 feet). The schists extend to Renvyle, and occur in Inishbofin and other islands. The famous Connemara marble or "Irish green" (see p. 39) is obtained from quarries at Ballynahinch, Lissoughter north of Recess, and Streamstown north of Clifden. Granite is quarried at Shan Talla, Barna, Oughterard, and other places. Joyces Country, which extends from the borders of Lough Mask to Leenane on the shores of Killary Harbour, is formed largely of Silurian rocks, which rise in bold green mountains, through the grassy covering of which the rocky framework is sometimes discernible. Benwee (2239 feet) is capped by Lower Carboniferous sandstone.

The Arran Islands, with their fine cliffs, their fissured and weathered rocks, and the greater part of eastern Galway, are formed of Carboniferous limestone. This rock extends from the town along the southern and eastern borders of Lough Corrib, northwards beyond Tuam, and eastwards to Ballinasloe, where it is much quarried for building-stone. The limestone, sometimes much drift-covered, elsewhere standing out in rugged forms at the surface, occupies the country as far as the borders of Lough Derg, and around Loughrea and Gort. Black marble is obtained from it at Menlough and Angliham north of Galway.

Sea-side resorts: Clifden, Leenane on Killary Harbour, Letterfrack, Renvyle, Salthill by Galway (sandy and rocky shores).

Kerry (Munster). Map 34b. Area 1,189,787 acres.

In this beautiful county of mountain and lake, with its deeply indented coast and fine cliff scenery, the so-called solid rocks play a more prominent part than elsewhere in Ireland, as although the land has been notably glaciated, it has been less extensively coated with Drift than other counties. Nevertheless more than half is under cultivation. The main features that form the promontories bordering Kenmare River and Dingle Bay, and the mountainous region that rises above the lakes of Killarney, are formed of the Lower Old Red sandstone—the Dingle Beds and Glengariff Grits. They extend to Valencia Island, where the rocks yield flaggy slates; and appear also in the Skelligs. They rise in the McGillicuddy's Reeks at Carrantuohill (Carrantual) the highest Irish mountain, to a height of 3414 feet, and at Purple Mountain and Tomies to heights of 2739 and 2413 feet—the two latter parted from the loftier mountain by the famous Gap of Dunloe (see Fig. 18, p. 137). Eastwards past the upper lake of Killarney, rises Mangerton (2756 feet), other mountains, and the Devil's Punch Bowl, a tarn 2206 feet above sea-level. The lower lake of

Muckross and Lough Leane, adjacent to Killarney, are situated on the Carboniferous limestone which extends seaward to Dingle Bay; and thence in a sinuous outcrop through Castleisland, Tralee, and Listowel, to the coast at Ballybunion, where it is hollowed out in caves. During the 18th century copper-ore was worked by the lower lake at Ross Island and Muckross near Killarney. The limestone is quarried for building-stone or marble at Kenmare, at Castleisland near Tralee, and Listowel.

Along the eastern mountainous borders of the county, the rivers Lee and Blackwater take their sources flowing through Cork. The grand inlet of Kenmare river has been excavated in a syncline of the Lower Carboniferous slates, grits and limestones.

The eastern part of Dingle promontory is formed of Upper Old Red sandstone, which rises in the Slieve Mish Mountains (upwards of 2700 feet) and occurs also at Kerry Head further north. It likewise appears in the fine cliffs of the Three Sisters near Smerwick. These rocks rest unconformably on the Dingle Beds. Dingle itself and Great Blasket Island are formed of the Dingle Beds. Brandon Hill, which is formed of Old Red conglomerate over Dingle Beds, rises to a height of more than 3000 feet. On the western end of the promontory, at Ferriter's Cove and Clogher Head, there is a patch of Silurian strata with contemporaneous volcanic rocks, and some intrusive rocks of greenstone and porphyrite (described in detail by C. I. Gardiner and S. H. Reynolds). Representatives of strata from Llandovery to Ludlow are met with, and they are overlain comformably by the Dingle Beds. Further north the Smerwick Beds are probably of Llandovery age.

The eastern part of the county from a little north of Killarney, to the coast at Leck Point and the borders of the Shannon, is formed of Upper Carboniferous rocks, including outliers of Coal-measures with a few thin coals in the Stacks and Glanruddery Mountains. Spa near Tralee has a chalybeate spring.

Sea-side resorts: Ballybunion, Fenit, Kenmare, Parknasilla, Waterville (rocky coasts with occasional strands).

Kildare (Leinster). Map 34b. Area 418,496 acres.

In this generally flat agricultural region, of pasture and arable land, the foundation rock is mainly Carboniferous limestone covered to a great extent with limestone-gravel and other drift deposits and much peat. The limestone has yielded good beds of marble.

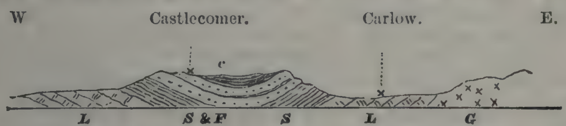
The most interesting geological area is that of the Kildare Hills to the north of the old cathedral city of Kildare. A series of rocks is here exposed, ranging from Ordovician (Bala limestones and shales) at the Chair of Kildare on Grange Hill (744 feet) to Silurian (Llandovery and Wenlock), exposed at the same locality, and also at Dunmurry Hill (769 feet) in the southern part of the range. Grange Hill, and the Hill of Allen (676 feet) to the north-east, are largely composed of basalts or andesites of Bala age. The Hill of Allen has given name to the great Bog of Allen, which extends from Monasterevin into King's County. A belt of Ordovician rocks extends along the south-eastern borders of the county, south of Naas, and these rocks are altered in the far south by contact with granite, a portion of the Wicklow Mountain granite, which there enters the county.

Kilkenny (Leinster). Map 34b. Area 511,775 acres.

This county contains a considerable variety of geological formations, and while largely agricultural, the rocks have yielded material of economic importance. The northern part is occupied by a considerable portion of the Leinster coal-field, an elevated basin, including Castlecomer, where anthracitic coal has been worked. At the Jarrow Colliery some remarkable Labyrinthodont Amphibia have been obtained, as well as many fish-remains.

The coal-field is based on the Millstone Grit and Yoredale rocks, a series of sandstones and shales, which extend to the western borders of the county. Flagstones known as "Carlow Flags," are obtained from Shankhill. Carboniferous limestone forms the foundation at Johnstown in the north-west; also at Kilkenny, famous for its black and white marble, the black marble being variegated with the white calc-spar of the fossil brachiopods. The limestone extends southwards to near Thomastown, beyond which a broad tract of Old Red sandstone, famous for fossils at Kiltorcan, together with Ordovician rocks, intrusions of granite and other igneous rocks, extend to the south-eastern confines of the county. In the Ordovician rocks slate is worked near Kilmoganny,

FIG. 20.—SECTION ACROSS THE LEINSTER COAL-FIELD. (*Hull.*)



C. Coal-measures.
S. & F. Yoredale shales and flags.
L. Carboniferous Limestone.
G. Granite.

and in the valley of the Lingaun on the borders of Tipperary. In the south-west the Carboniferous limestone again appears, here and there, amid coverings of Drift.

King's County (Leinster). Map 34b. Area 493,999 acres.

This county, a part of the great Central Plain of Ireland, is almost wholly a Drift-covered area, with much peat-land, over Carboniferous limestone. It is essentially a flat agricultural region, and it includes a considerable part of the Bog of Allen, in the area from Portarlington to Edenderry and Tullamore. The south-western portion of the county is, however, diversified by the Slieve Bloom Mountains, formed of Old Red sandstone and Ordovician rocks, which rise on the borders of Queen's County to upwards of 1700 feet. The limestone has been quarried for marble and building-stone at Edenderry, Tullamore, and other places.

Leitrim (Connaught). Map 34a. Area 392,381 acres.

This county extends from the shores of Donegal Bay, where it possesses a coast-line of about four miles at Tullaghan, a few miles south-west of Bundoran. The greater part of the area is based on Carboniferous rocks; the lower beds of limestone extend from the sea-coast to the borders of

Lough Gill, to the south of which a belt of metamorphic rocks stretches nearly across the county. Beyond this the limestone continues to the foot of the Lackagh Hills (1448 feet), formed of Upper Carboniferous; and these higher rocks extend through the region occupied by Lough Allen to Bencroy and Slieve Anierin (1922 feet), the summits of which are outliers of Coal-measures. In this area from the Upper Carboniferous limestone, the succession is continued through Yoredale sandstones (impersistent), Yoredale shales, and Millstone grit (with two coal seams), to the Lower Coal-measures. Flagstones are obtained from the Upper Carboniferous rocks.

The southern part of the county, based mostly on Carboniferous limestone and underlying sandstones, is much Drift-covered, and forms an agricultural district. It is low-lying, boggy, and dotted with small loughs; but its boundary on the west extends to the picturesque and fertile shores of the Shannon at Drumsna (with a sulphurous spring) and Carrick-on-Shannon. Ordovician rocks appear in places along the southern borders.

Limerick (Munster). Map 34b. Area 680,842 acres.

In this fertile pastoral county, with its dairy farms and grazing lands, the greater part of the area is formed of Carboniferous limestone, extensively covered with Drift.

Old Red sandstone and Ordovician rocks appear on the eastern borders, rising at Slievefelim to 1523 feet, and in the south-east to more than 1300 feet. Belts of Old Red sandstone also appear to the south of Croom. The Carboniferous limestone occurs on the borders of Co. Cork, north-east of Mitchelstown, and contains some notable caves with stalactites.

The northern borders of the county follow the course of the Shannon, from Castleconnell, and there the great river flows over a rocky limestone-bed in the falls and rapids of Doonass.

The limestone yields red marble at Adare and Clorhane. Igneous rocks (porphyrites, andesites, and basalts) appear near Limerick and Pallas Green in the Carboniferous limestone.

On the western borders of the county the Upper Carboniferous rocks with Coal-measures occupy a broad belt.

Londonderry (Ulster). Map 34a. Area 522,315 acres.

This county, which exhibits considerable diversity in feature and geological structure, extends from the borders of Lough Foyle inland to the shores of Lough Neagh. The eastern borders are formed by the margin of the great basalt plateau of Antrim which rises west of Coleraine, to a height of 1260 feet at Binevenagh, with Keady Mountain (1101 feet) and St. Donald's Hill (1318 feet), to the east and south-east of Limavady. Beneath this scarp there is a belt of Cretaceous rocks, and below Binevenagh also Lower Lias, and Rhætic Beds, based on New Red rocks. Cretaceous and New Red rocks also appear beneath the basalt at Churchtown on the southern borders of the county. Along the western margin of the basalt from the borders of Lough Foyle southwards through Limavady, there also occur belts of Lower Carboniferous sandstone and limestone. The sandstone is worked for building-stone at Dungiven. Small tracts of Old Red Sandstone, and intrusions of granite and other igneous rocks occur in and near Slieve Gallion (1623 feet). An outlier of Chalk occurs at an elevation of about 1400 feet on this mountainous tract. Schistose rocks extend westwards, and rise in the Sperrin Mountains to 2240 feet at Mount Sawel, on the borders of Tyrone. These old rocks form the foundation at Londonderry (Derry) and at Magilligan Point at the entrance to Lough Foyle: there covered by raised beach and blown sand, and elsewhere by intakes of mudland. By the mouth of the river Foyle the basal Carboniferous rocks, sandstones and conglomerates extend along the shores of the Lough, beneath the recent deposits.

Sea-side resorts: Castlerock Downhill, and Portstewart.

Longford (Leinster). Map 34a. Area 269,409 acres.

This small central county, much of it Drift-covered Carboniferous limestone, comprises flat pastoral land, with sheep farms and grazing grounds, and a good deal of peat-bog. The Limestone yields marble. Ordovician rocks form uplands on the northern part of the county and extend along the borders of Lough Gowna; and at Longford there are inlying tracts of Old Red Sandstone among the Carboniferous rocks.

Louth (Leinster). Map 34a. Area 202,731 acres.

The greater portion of this, the smallest Irish county, is based on Silurian rocks, from Dundalk southwards to Clogher Head. Much of this coast and of the county generally is covered with Drift, and it constitutes a fertile pastoral region. Carboniferous limestone extends along the southern borders at Drogheda, on the river Boyne. This formation appears also at Ardee, in outlying masses to the north of Dundalk, and along the base of the Carlingford Mountains, bordering the northern shore of Dundalk Bay: thence, much concealed by Drift and recent estuarine and marine deposits, it extends to Greenore, at the mouth of Carlingford Lough.

The picturesque mountain tract of the Carlingford peninsula with Carlingford Mountain (1935 feet) is formed mainly of granitic rock (granophyre) which appears also at Clermont Carn (1674 feet) connected with the protrusion of Slieve Gullion in Armagh. The granophyre has invaded an earlier mass of gabbro, which is seen at Barnavave (1142 feet). Intrusions of rhyolite have also been observed. These eruptive rocks are compared with those of Tertiary age in Skye.

Sea-side resorts: Carlingford, Greenore (sands).

Mayo (Connaught). Map 34a. Area 1,380,390 acres.

This picturesque and largely mountainous county is divided into two portions by the broad inlet of Clew Bay, and by the upland region of schists, which extend to the north-eastwards by Lough Cullin to the Slieve Gamph Mountains. This range forms a kind of wedge between areas of the Lower Carboniferous series that otherwise form the main foundation of the eastern parts of the county. The basal sandstones of this series are 1000 feet thick in places

In the south the Carboniferous series (mainly limestone) extends from the shores of Loughs Corrib and Mask, through Clare to Castlebar and the eastern borders, modified only by tracts of Old Red sandstone, near Ballyhaunis, and of Old Red sandstone and Silurian on the southern borders of Sligo. There are caverns in the neighbourhood of Cong between the two Loughs, and their waters are connected by a river which flows underground. In the north the Limestone series extends from the borders of Lough Conn to Ballina, on the River Moy, and Killala Bay.

Along the coast westwards to Downpatrick and Benmore Heads the Lower sandstones appear in force. The Limestone, as before mentioned, borders Clew Bay, forming the foundation from Murrisk Abbey by Westport to Newport, and the coast near Mallaranny. This area, as is the case with the eastern tracts of Limestone Series, is largely covered with Drift; and the peculiar features of Clew Bay, with its numerous tiny islets, are due to the erosion of a slightly submerged vale that was thickly covered with Boulder drift. The islets formed of this accumulation are protected by fringes of the boulders that have fallen from the low cliffs.

The western portions of Mayo form a grand mountainous and rocky region. On the northern shores of Killary Harbour the Silurian rocks extend some way up the Erriff valley and through Delphi towards Lough Dhu or Doolough, where Ordovician rocks occur. In this region Mweelrea on the west rises to 2688 feet, and Bengorm 2303 feet; while on the east the Partry Mountains west of Lough Mask are formed of Silurian rocks and schists, with a belt of Carboniferous sandstones and limestones, rising at Bohaun to 1294 feet. To the north of Lough Dhu is a bold region of schists with Benlugmore (2618 feet) and Benbury (2610 feet) on the west, and Glenummerra (2474 feet) and other mountains to the east. In the centre of this region there is a mass of granite.

On the southern borders of Clew Bay rises the conspicuous conical mountain of Croagh Patrick (2510 feet) formed of pre-Silurian quartzite. Serpentine occurs between this region and Westport. Clare Island, at the entrance to Clew Bay, is formed of Ordovician and Silurian rocks, with Carboniferous on the east; while Inishturk to the south is formed of Ordovician. To the north of Clew Bay, a mass of Old Red sandstone occurs on the south-east of the Curraun Peninsula, bordering quartzites and schists which extend to Owenduff on the north, and over Achill Island, the largest of Irish islands. Achill is noted for its bold and precipitous cliffs, which rise at Croaghaun, by Achill Head, and at Slievemore, to nearly the heights of the adjacent mountains, 2192 and 2204 feet. The island is connected by an iron bridge with the mainland.

The north-western portions of Mayo are formed mainly of similar schists and quartzites. There are many rocky inlets from Blacksod Bay to Broadhaven and Benwee Head, and the geological structure is varied by intrusions of granite and occasionally of other igneous rocks. There is much bog on the uplands, and blown sand fringes many of the bays.

The older rocks occupy nearly half the county, forming a region of mountain, moor and bog; while the Carboniferous areas of the plains of Mayo, so largely Drift covered, are mostly under cultivation as pasture land, with tracts under tillage, and likewise many areas of peat.

Black marble is obtained from the Carboniferous limestone.

Sea-side resorts: Mallaranny (sands), Westport (famous for its picturesque surroundings).

Meath (Leinster). Map 34a. Area 579,320 acres.

In this gently undulating pastoral county the foundation rocks comprise a tract of Silurian which extends from the borders of Cavan through

Kells, and Slane to the margins of Louth. Near Slane andesites and other igneous rocks appear among the strata. To the north there is a tract of Carboniferous limestone with overlying Millstone Grit and Coal-measures north of Nobber, and a belt of New Red rocks on the west. Dolerite is here intrusive in Coal-measures and in the Triassic sandstones and marls.

From the borders of Lough Sheelin, in the north-west, to Navan, Slane, and the mouth of the Boyne, Carboniferous rocks extend to the southern limits of the county; the Limestone being covered by patches of Millstone Grit at Trim in the vale of Boyne, in the famous Hill of Tara, and in adjacent tracts to the north-east and south-west. Fine cliffs of contorted Carboniferous limestone appear at Beauparc on the Boyne, above Slane. A mass of Silurian strata occurs in the area of Duleek and extends to the sea-coast near Laytown, and at Benhead on the borders of Co. Dublin.

The area is largely covered with Drift deposits, upon which its fertility depends, much of the land being excellent grazing ground, with many tracts under tillage.

The coast-line is low and the shore sandy.

Sea-side resorts : Betaghstown, Laytown.

Monaghan (Ulster). Map 34a. Area 319,741 acres.

This is an undulating and hilly county, occupied by a considerable area of Silurian rocks, which extend from near Monaghan through Ballybay and Castleblaney to the southern borders of the county. Traversing that region there are belts of Carboniferous limestone and Coal-measures, with New Red rocks faulted against the Silurian to the west and south-west of Carrickmacross. From Clones and Monaghan northwards the Carboniferous limestone series extends to the borders of Tyrone and Fermanagh, with an overlying tract of Millstone Grit, which rises to 1255 feet in Slieve Beagh at the junction of the three counties. Separating this tract of Carboniferous rocks from the Silurian, is a belt of Ordovician strata which crosses the county to the south of Clones and Monaghan; and there is a small area of these older rocks south-west of Ballybay.

Great part of the county is Drift-covered; it forms a good agricultural district, much of the land being under arable cultivation.

Queen's County (Leinster). Map 34b. Area 424,723 acres.

Much of this county forms part of the great Central Plain of Ireland, and is a Drift-covered pastoral area, with tracts of peat, based on Carboniferous limestone. The land, however, rises in the south-east, where the northern portion of the Leinster Coalfield extends towards Maryborough; while to the north-west of that town, Old Red sandstone and Ordovician rocks rise in the Slieve Bloom Mountains, to 1667 feet in the Ridge of Capard, to 1661 feet in the Cones, and to 1733 feet in Arderin on the borders of King's Co. Bog iron-ore has been worked near Mountrath.

Roscommon (Connaught). Map 34a. Area 629,633 acres.

The greater part of this county is underlain by Carboniferous limestone with its basement sandstone, extensively Drift-covered; from Boyle to Roscommon, and from the borders of Lough Ree to the river Suck and the southern limits of the county. On the western side the monotony is broken by a small tract of Old Red sandstone to the south-west of Roscommon, and by other tracts west and south-west of Castlereagh; while on the eastern side there are Silurian inliers east of Kilglass and at Slieve Baun (857 feet) above Clooncah. Much of this area is a pastoral region, interspersed with peat-bogs and numerous loughs: and the northern part especially, known as the "Plain of Boyle," is a famous grazing land for sheep and cattle. To the north of Boyle the Curlew Mountains, formed of Old Red sandstone, rise to 765 feet, from the borders of Lough Key, with its numerous islets. Still further north there is a small tract of Carboniferous limestone; and beyond, the Upper Carboniferous rocks of the Arigna coal-field extend from the shores of Lough Allen to the Bralieve Mountains. There Cashel, on the borders of Leitrim, rises to 1377 feet, and is crowned by an outlier of Coal-measures. Coal and iron-ore have been worked in this district; some of the rocks yield flagstones, while building-stone and marble are obtained from the Carboniferous limestone.

Sligo (Connaught). Map 34a. Area 452,356 acres.

This is a picturesque and mountainous country, and although formed largely of Carboniferous limestone, which elsewhere occupies so much of the lower grounds, the formation here rises to elevations of 1527 feet at King's Mountain, 1712 at Benbulbin, 2113 at Truskmore to the north of Sligo, and to 1078 feet at Knocknarea on the east. The sea-borders are formed of the Lower Carboniferous rocks, with basal sandstones, and with much drift; and they constitute an undulating pastoral tract, with picturesque indentations in Sligo Bay, but the cliffs are nowhere very lofty, and the tidal inlets are stony and muddy at low water. Nevertheless the seaport town is finely situated, with the bordering mountainous ranges of limestone, while the beautiful Lough Gill extends to the irregular range of schists and quartzites that rise to 967 feet at Slieve Slish. Westwards of Collooney this belt of old rocks forms the Ox Mountains with Knockalongy (1778 feet), a range which separates the Carboniferous limestone of Sligo on the north from another tract on the south; the latter in part a pastoral vale, with many Eskers and Drift mounds, which, however, rises into mountainous ground upwards of 1000 feet high, on the west of Lough Arrow, and extends southwards to the Old Red sandstone of the Curlew Mountains which rise to 815 feet on the borders of the county. To the south-east the Bralieve Mountains with Carrow (1498 feet) are formed of the Upper Carboniferous strata.

Near Kesh, at the foot of Keishcorran (1183 feet), one of the mountains of Carboniferous limestone west of Lough Arrow, there are a number of caves from which Dr. R. F. Scharf and others have obtained remains of reindeer, arctic lemming, bear and wolf, also relics of man. The caves afford evidence of occupation in Neolithic and later times.

Sea-side resort: Rosses Point, Sligo.

Tipperary (Munster). Map 34b. Area 1,062,963 acres.

In this large county there is considerable diversity of scenery. The comparatively flat pastoral regions on the Drift-covered Carboniferous limestone extend over the northern part of the county from Nenagh and the north-eastern shores of Lough Derg, near Puckaun; another broad tract occupies the Suir valley, through Templemore and Thurles to Golden, which gives name to the fertile Golden Vale, between Tipperary and Cashel, and is continued eastwards to Fethard, and along the south-eastern borders of the county to Clonmel and Carrick-on-Suir. In these areas there is much pasture-land with dairy farms, and many arable tracts where wheat, oats and barley are grown. On the eastern borders there is a tract of Upper Carboniferous rocks, including the East Munster or Tipperary coal-field, a small productive tract, an offshoot from the Leinster (or Kilkenny) coal-field. The irregular folds and basins of Carboniferous rocks are indicated by the bordering tracts of Old Red sandstone. The Rock of Cashel (300 feet) is an anticline of the Limestone adjacent to an outlier of Upper Carboniferous strata. In the south-west the Old Red sandstone rises in the Knockmealdown Mountains, 2609 feet, and again west of Caher in the Galtee (Galty) Mountains, with Galtymore 3015 feet; a range which includes a tract of Ordovician on the Limerick borders. A belt of Old Red sandstone rises to the south-west of Tipperary, in Slievenamuck, 1215 feet, and another to the north-west of the town. The disturbances which upraised these rocks extend eastwards from Caher to Slievenaman (2364 feet), south-east of Fethard, where Old Red sandstone with a core of Ordovician again occurs.

To the north of Tipperary a broad belt of Ordovician rocks with fringes of Old Red sandstone extends across the county, forming the Keeper Mountain (2278 feet) with Mauherslieve (1783) and Devil's bit (1583). Of this range the northern part constitutes the Silvermines Mountains (1587 feet); and argentiferous galena was at one time worked on the borders of the Ordovician and Carboniferous limestone. A small tract of Carboniferous limestone occurs around Roscrea, to the north-east.

Still another tract of Ordovician and Old Red sandstone extends from the neighbourhood of Nenagh to the southern borders of Lough Derg. In this tract the older rocks yield slates, north of Ballina, and they rise to 1517 feet in the Arra Mountains.

Tyrone (Ulster). Map 34a. Area 806,658 acres.

Representatives of many geological formations are met with in this hilly and mountainous county. In the northern parts schists extend through Strabane to the Sperrin Mountains, which rise upwards of 2000 feet; they occur north of Pomeroy, near Omagh, around Newtown Stewart, and thence extend to the western borders. At Pomeroy there is a small tract of Ordovician and Silurian rocks; while considerable areas of diorite and some bosses of granite occur to the north and west. Lower Carboniferous sandstones and shales appear at Mulvin, and also at Omagh, fringed on the north by Old Red sandstone. The southern portion of the county from Irvinestown to Fintona and Slievemore (1055 feet), is occupied by Old Red sandstone, with included andesites at Cappagh, and is much Drift-covered. This area is bordered by the Carboniferous limestone series at Clogher and Ballygawley, with Upper Carboniferous in the far south, rising at Slieve Beagh to 1255 feet. Productive coal-measures occur in the Tyrone coal-field between Dungannon and Coalisland in the east. There good bituminous or household coal is obtained. The Annagher seam is 9 feet thick. New Red rocks also occur on the south-eastern borders of the county, covered on the margin of Lough Neagh in places by Cretaceous rocks and basalt, and elsewhere by the Lough Neagh beds.

Marble and sandstone for building-purposes are obtained from the Carboniferous rocks: and there is a good deal of fertile agricultural land in this diversified county.

Waterford (Munster). Map 34b. Area 458,108 acres.

This hilly, and in part mountainous, county, is formed largely of Old Red sandstone, with belts of the Carboniferous limestone series in the south-west at Lismore and Dungarvan, and in the Drum Hills. The rocks yield marble near Cappoquin and Whitechurch.

In the north-west the Old Red sandstone forms the Monavullagh Mountains (an eastern extension of the Knockmealdown range); and further north towards Clonmel they rise in Knockanaffrin (2478 feet).

At Coumshingaun there is a tarn more than 1100 feet above sea-level; this lies among the Comeragh Mountains, in part Ordovician. This range, with its numerous corries, is glaciated to a height of about 1000 feet. The older rocks, with abundant intercalations of felsite, extend to the coast south of Waterford, while at Brownstone Head and Dunmore at the entrance to Waterford Harbour, the Old Red sandstone again occurs.

The coast, and much of the eastern part of the county is low-lying; and there is a mixture of agricultural land, where dairy farming is carried on, with less productive and peaty tracts.

Copper-ore has been worked at Knockmahon on the south coast. Slates have been quarried in the Ordovician rocks at Glenpatrick, and near Kilmacthomas.

The Caves at Shandon, near Dungarvan, have yielded mammalian remains, including mammoth, bear, and reindeer.

Sea-side resorts: Dunmore, Tramore (with cliffs, caves, and fine sands).

Westmeath (Leinster). Map 34a. Area 454,104 acres.

This fertile county of pasture and arable land is a Drift-covered region based almost wholly on Carboniferous limestone: the only exceptions being inliers of Old Red sandstone near Moate, and east of Mullingar. The surface is diversified with several extensive loughs, and other smaller sheets of water, and by peaty areas. Building-stone and marble are obtained from the Carboniferous limestone.

Wexford (Leinster). Map 34b. Area 576,757 acres.

On the whole this is a low-lying and pastoral country, with much ground under tillage, barley being one of the products.

Though consisting largely of Ordovician rocks, with numerous intercalated beds of felsite, these igneous rocks seldom enter conspicuously into the form of the ground. The slates and grits have yielded Bala fossils at Ballymoney. They rise at Slieve Boy (1385 feet), north of Ferns, and at Vinegar Hill (1798 feet), north-east of Enniscorthy. Slates have been quarried near Newtownbarry.

The highest land is on the borders of Carlow, where the granite enters the county, and rises in Mount Leinster (2610 feet) and Blackstairs Mountain (2409 feet). A small tract of granite also protrudes in the area south-east of Enniscorthy.

From Cahore Point Cambrian rocks form a broad belt along the eastern sea-borders, and extend through Wexford to the south coast at Bannow.

Carboniferous limestone occurs along the northern side of Wexford Harbour; and from the south-western side, fringed by Old Red sandstone, it extends to the coast, and also forms the promontory of Hook Head, to the east of Waterford Harbour. Marble has been obtained in places.

Rosslare Point and Raven Point are formed of spits of recent marine deposits and blown sand. To the south by Rosslare Harbour there is a small area of Ordovician rocks, and a belt of Cambrian which extends from Greenore Point to Ballyteige Bay. Granite forms the headland of Carnsore Point. The Tuskar Rock, on which a lighthouse is placed, lies east of the headland.

The Saltee Islands, off the south coast, are formed of schists. Boulder clay, sands and gravels extend over much of the country.

The east coast is mostly low and Drift-covered, and there is a good deal of blown sand.

The so-called 'Manure gravels' of Wexford have yielded many mollusca, some of which may have been derived from accumulations of Pliocene age: the beds include much shell-sand which has been used for agricutural purposes.

Sea-side resorts: Cahore, Duncannon (on Waterford Harbour).

Wicklow (Leinster). Map 34b. Area 500,216 acres.

In this picturesque county, not undeservedly called 'the Garden of Ireland', the main structure is formed of the Cambrian and Ordovician rocks, through which a broad belt of granite has been intruded; and this rising in the Wicklow mountains forms the dominant features, among which Kippure Mountain (2473 feet) in the north, Duff Hill (2364 feet) and Lugnaquilla (3039 feet) are conspicuous. The granite is quarried near Blessington. Belts of altered Ordovician rocks fringe the granite on either side; and in fissures along these belts many metalliferous minerals have been accumulated. Silver-lead mines have been worked near Glendalough, a locality more famed for its Seven Churches, its picturesque loughs, and bold mountains.

Through the south-eastern part of the county, from near Wicklow Head to the Vale of Clara and Rathdrum, along Glenmalure, and the Vale of Ovoca, the scenery among the Ordovician rocks comprises charming wooded hills and rocky vales. In places the strata are traversed by many bands of felsite, and intrusions of dolerite, &c.; and they have yielded at Ovoca copper-ore and pyrites. At an early period gold was found in the region south-west of Woodenbridge, at Ballinvalley; in the alluvial deposits of "Gold mine river", a stream which flows into the Aughrim river above Ovoca. A little tin-ore has also been found with the gold.

Arklow Head is formed partly of dolerite that is quarried for paving-setts. Terra-cotta clay has been worked at Arklow.

Cambrian rocks extend southwards over a broad tract of country, from the bold foreland of Bray Head (653 feet) towards Wicklow; and slates have been worked in this formation near Ashford and the Devil's Glen, above Glenmore Castle. Much of the coast land is low, being a drift-covered plain, fringed from Wicklow to near Greystones by a shingle bank known as "The Murrough," but the ancient quartzites rise westwards, and form the prominent conical hill of the Great Sugar Loaf (1659 feet), also the Little Sugar Loaf (1120 feet), situated in the northern part of the county, near Enniskerry. The Scalp, not far off, is a gorge in the granite. (See p. 146.) In this region the river Dargle, rising in the granite mountains in the west, flows through a charming rocky defile, along the borders of Cambrian and Ordovician rocks, with a fine waterfall (300 feet) at Powerscourt. Poulaphouca Waterfall (150 feet) is on the western side of the granite range on the Liffey, south-west of Blessington.

Seaside resorts: Bray (cliffs and sands), Greystones, Wicklow.

The following works may be consulted with special reference to the Scenery and Geology of Ireland. (See also p. 101):—

G. A. J. Cole and J. R. Kilroe in Ireland Industrial and Agricultural (Department of Agriculture and Technical Instruction for Ireland), 1902.
E. Hull. The Physical Geology and Geography of Ireland. Ed. 2. 1891.
G. H. Kinahan. Manual of the Geology of Ireland. 1878.
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FEATURES OBSERVABLE ALONG THE PRINCIPAL LINES OF RAILWAY.

I. DUBLIN, WICKLOW, AND WEXFORD RAILWAY.

Dublin to Bray, Wicklow, Rathdrum, Wexford, and Waterford.

MAP **34b** Starting from the station at Harcourt Street, **Dublin,** we pass through the southern suburbs of the city at Rathmines, Ranelagh, and Milltown, noticing by the way the stone-walls that here, as in many other towns in Ireland, border the high roads and sometimes the railway, and veil the scenery for long distances. We have crossed a tract of Carboniferous limestone covered with Drift, openings in which may be seen near Milltown. Near Dundrum we enter the picturesque region of the Wicklow granite, and pass through cuttings of this rock. A prominent feature a few miles to the south is the Three Rock Mountain (1469 feet). Through Stillorgan and Carrickmines to near Bray we cross a Drift-covered and cultivated tract of low land, with some cuttings in boulder gravel. To the west of Shankill the chimney of the Ballycorus lead-mines stands out conspicuously on the uplands. A little further on we join the coast-line from Westland Row.

Leaving **Dublin** at Westland Row station we pass through the south-eastern part of the city, with Donnybrook on the west, over Drift-covered Carboniferous limestone. Thence skirting the shore of Dublin Bay, with a fine view of Howth Head (Cambrian) to the north, we enter the granite region at Blackrock, and traverse it by Monkstown, **Kingtown,** and Dalkey. The rock stands out boldly in the Killiney Hills and in Dalkey Island. Proceeding along the shore of Killiney Bay, we leave the granite area and pass across a belt of Ordovician to the Cambrian rocks of **Bray.** Skirting this bold and rocky coast, the railway passes through tunnels and cuttings in the folded grey and purple grits and slates of Bray Head, covered here and there by Drift gravel. Fine views of the

Great Sugar Loaf (1659 feet) and of the Little Sugar Loaf (1120 feet), east of it, both formed of Cambrian rocks, are to be seen as we approach Greystones and Delgany. Here we traverse a flat Drift country, the underlying Cambrian rocks appearing only in places. Onwards through Newcastle to **Wicklow,** there is much alluvial and meadow land bordered by woodlands on the Cambrian uplands to the west. As we approach Wicklow we pass on to the Drift-covered Ordovician rocks; and alongside the River Vartry, which flows through a narrow lough (termed Broad Lough), hemmed in by a shingle bank, and enters the sea north of Wicklow. The comparatively low headland of Wicklow is formed of slaty Ordovician rocks.

From Wicklow to Rathnew and Glenealy, we journey over a Drift-covered grassy country with fine hedgerows, and after traversing cuttings in Ordovician slates and Igneous rocks, we cross the noble valley of the Avonmore and enter **Rathdrum.** Thence we traverse the picturesque wooded valley of the Avonmore, its steep banks formed of Ordovician slates and grits and many bands of Igneous rock ; and we pass into the Vale of Ovoca, near "the Meeting of the Waters" of the Avonmore and Avonbeg. At **Ovoca** evidences of mining activity are manifest in the heaps of white and yellow (ochreous) earth, tipped along the borders of the valley. The region is well-known for its copper ores, but pyrites, utilized in the manufacture of sulphuric acid by the Dublin and Wicklow Manure Company at Wicklow, is now the chief ore obtained Gold has been found along the Gold Mines River to the south-west of Woodenbridge. After leaving Woodenbridge (the junction for Shillelagh) we pass through cuttings in Ordovician rocks, and from this more hilly woodland district we now enter a flatter Drift-covered tract of grassland, which forms the vale of Arklow. Arklow Head is formed by dolerite and other eruptive rocks.

From **Arklow** we continue over the Drift-covered Ordovician series with its interbedded volcanic rocks, through an undulating country of pasture and tillage, with cuttings in gravel near Gorey. Now and again a more prominent mass of igneous rock diversifies the scenery, as in Tara Hill (826 feet), near the coast, north-east of Gorey ; while the Wicklow and Carlow granite mountains rise far away to the north-west. From Ferns, with its ruined castle, we have a view northwards of Slieve Boy (1385 feet), Ordovician.

We now traverse the valley of the Slaney past **Enniscorthy,** with cuttings in igneous and slaty rocks, to Macmine Junction. Here we again travel over a low-lying agricultural district, for the most part pasture-land. The railway to **Wexford** follows the right bank of the Slaney, over a tract of Cambrian rocks, with a view of Ferry Carrig Castle on the opposite side of the river. From Wexford the route lies along the borders of the shallow Harbour of Wexford, based on Carboniferous limestone and Cambrian rocks, and thence extends to the new Harbour of **Rosslare.**

From Macmine Junction, westwards to New Ross, the route is across Ordovician slates with belts of igneous rock. Much of the country is flat grassland, but beyond Palace East we traverse several cuttings and tunnels in the slaty rocks, and after crossing the River Barrow arrive at **New Ross.** Thence we cross a drift-covered tract, mostly of Ordovician rocks, bordered on the north-west by Old Red sandstone, and reach the banks of the River Suir at **Waterford.**

II. GREAT SOUTHERN AND WESTERN RAILWAY.

Dublin to Mallow and Cork.

MAP **34b** Leaving Kingsbridge Station, Dublin, we traverse a comparatively flat Drift-covered area of Carboniferous limestone as far as Charleville. This area belongs to the great Central Plain of Ireland, which is for the most part under 300 feet.

Phœnix Park lies to the north-west of the Terminus, Kilmainham to the south, and beyond in this direction rise the Granite mountains of Dublin and Wicklow (over 2000 feet in places). We pass near Lucan, which, possessing a sulphur spa, is a "health resort." It lies to the north by the River Liffey. Our immediate route is but little diversified ; grassland prevails in this flat region. Beyond **Newbridge** we cross an open undulating gorsy tract, with cuttings in Drift gravel and sand, and pass near the military camp of the Curragh, an extensive area famous also as a pasture ground for sheep. To the north-west is an upland tract of Ordovician rocks and Old Red sandstone, with igneous rocks, including Dunmurry Hill (769 feet) and the Chair of Kildare (744 feet). Through **Kildare** and **Portarlington** and onwards to **Maryborough** we continue on the plain, with occasional cuttings in Boulder Drift and Carboniferous limestone. Westwards the Slieve Bloom mountains (Old Red sandstone and Ordovician) rise to heights of a little over 1660 feet in the Ridge of Capard and the Cones, and to 1733 feet at Arderin. From **Mountrath** we have glimpses of the uplands of the Leinster coal-field that lies to the south-east.

At **Templemore** we journey to the south-west of another tract of Old Red sandstone and Ordovician, the older rocks rising to 1583 feet in the Devil's Bit Mountain. At **Thurles** we traverse the Suir valley, and pass through undulating pasture-land to **Limerick Junction.** The station is situated a little north of Tipperary, and of a wooded region that is backed by the range of the Galtee Mountains (Old Red sandstone and Ordovician). Thence between **Charleville** and Mallow we enter a more diversified country, crossing the western portion of the Galtee Mountains, known as the Ballyhoura Hills (Old Red sandstone), and afterwards a tract of Coal-measures to the north of **Mallow.** The town is pleasantly situated on the river Blackwater. Leaving it our route lies through a hilly country of Old Red sandstone to Blarney and its Castle, in the tower of which is the famous Blarney Stone ; and thence through tracts of Old Red sandstone and Carboniferous slate, much Drift-covered, we reach **Cork** and the river Lee.

Mallow to Killarney, Kenmare, and Tralee.

MAP **34b** From **Mallow** onwards to Banteer, Millstreet and Rathmore, the railway passes up the valley of the Blackwater, along a flat or gently undulating vale of Drift-covered Carboniferous limestone and Old Red sandstone, the latter rising on the south in the Bochragh or Boggeragh Mountains (upwards of 2000 feet). The country as far as Headford, mostly under pasture, is diversified with stone-fences and gorse-hedgerows, with woodland and tracts of peat, as well as with areas under tillage. The railway beyond Millstreet passes on to the Upper Carboniferous shales and grits, which are exposed in a cutting by Rathmore Station, and we continue over Drift-covered tracts of the same rocks to near **Headford Junction.** The mountains of Old Red sandstone (Glengariff Grits), bordered by scarps of rough rock, stand out boldly to the south. Near Headford Station we cross a tributary of the Flesk, known as the River Quagmire, a name appropriate for a peaty district in which the bursting of a bog is not unknown.

The rail to **Kenmare** passes through a mountainous region of Glengariff Grits, and over a narrow belt of Carboniferous limestone. Evidences of glaciation are conspicuous along the route.

From Headford to **Killarney** we traverse a Drift-covered tract of Carboniferous limestone along the borders of the rapid river Flesk, through stony pastures, gorse-covered hills, and many peaty tracts, with fine views of the mountains. From Killarney to Farranfore we cross a wooded and grassy country, in the Upper Carboniferous rocks, with much boulder gravel and peat, and a few rock-cuttings. The fine mountains of the Dingle promontory (Old Red sandstone and Dingle Beds) stand out to the west. Beyond Farranfore the Upper Carboniferous hills rise to the east, and we cross a tract of Drift-covered Carboniferous limestone, with much peat, to **Tralee.**

Waterford to Limerick.

MAP **34b** Leaving **Waterford** Station, along the Suir Valley, we traverse hilly ground formed of Old Red sandstone and conglomerate, and then enter an undulating pastoral vale of Drift-covered Carboniferous limestone, with occasional cuttings in the rock on our way to **Carrick-on-Suir** and Clonmel. The Comeragh Mountains (Old Redsandstone and Ordovician) rise in places more than 2000 feet to the south, and similar rocks form the heights on the north, with Slievenaman (2364 feet).

Beyond **Clonmel** we see on the south-west the irregular outlines of the Knockmealdown Mountains (Old Red sandstone), but the railway traverses the Carboniferous limestone and Drift to **Caher.** To the west the fine range of the Galtee Mountains (3015 feet), formed of Old Red sandstone and Ordovician, extends to near **Caher.** Beyond that town we pass through a cutting in Old Red sandstone on the borders of the Suir, and then traverse a low-lying grass country, the "Golden Vale," a part of the Central Plain, mainly Carboniferous limestone thickly overspread with Drift sand and gravel.

Before reaching **Tipperary** we cross a belt of Old Red sandstone, which rises to the south-west of the town at Slievenamuck (1215 feet). Thence past Limerick Junction to **Limerick,** although the underground geology is varied by the presence of igneous rocks interbedded with and intrusive in the Carboniferous limestone, we pass over a flat or slightly undulating and for the most part Drift-covered district, famous for its dairy-farms.

Limerick to Ennis, Athenry, Claremorris, Westport, and Sligo.

MAP **34b** From **Limerick** Station we journey on a low-lying Drift-covered tract of Carboniferous limestone, and crossing the Shannon pass over Alluvium to Long Pavement. Traversing a cutting in the limestone we enter an undulating grass country on the borders of the Lower Shannon, with peeps of the broad river to the south. At Cratloe we cross a tract of Old Red sandstone, which rises with the Ordovician rocks to form the Slieve Bernagh range (1746 feet) on the north-east. Thence to Collooney near Sligo, the railway traverses a tract based on Carboniferous limestone, with an ever varying amount of Drift.

For the most part a tolerably flat region of pasture-land, with some tracts under arable cultivation, it is pleasantly diversified.

Scars of limestone and irregular bosses of the rock protrude from the pastures, and stone-fences alternate with luxuriant hedge-rows. We pass occasional small loughs and boggy tracts where peat is dug, and ere we reach **Ennis** we cross broad tracts of alluvial ground bordering the river Fergus.

Beyond Ennis the character of the limestone country is more pronounced; we enter a vale of rocks with scars and crags and many blocks of limestone. To the south of Crusheen and on the east of the railway we pass Lough Inchicronan, beyond which to the north-east rises a mountainous tract of Old Red sandstone and Ordovician with Knockaniss (1312 feet).

Through Tubber, Gort, and Ardrahan the scene constantly varies, and we pass from peat-grounds to rocky vale and woodland. Beyond Craughwell and **Loughrea** we come to a veritable desert of stone—a tract of enclosed ground divided by stone-walls, and occupied almost as much by bosses and blocks of limestone as by pasture.

MAP **34a** From **Athenry** to **Tuam**, beyond which we cross the rivers Clare and Robe, and thence to **Claremorris**, the limestone is for the most part hidden by Drift, Alluvium and Peat, the Drift rising now and again in Drumlins and Esker mounds. The railway by **Castlebar** to **Westport** for the most part traverses a country of Drift and bog-land. Far to the west rise the Partry Mountains of Connemara formed of Silurian rocks and Archæan schists.

From **Claremorris** we journey over an undulating agricultural and moory country, the cultivated mounds of Drift rising prominently here and there like oases in a desert of peat.

From near Kiltimagh to Swineford and Curry we cross tributaries of the river Moy, which flows into Killala Bay. To the north-west and north rise the Slieve Gamph and Ox Mountains (Archæan rocks); while to the south and south-east of **Charlestown,** uplands of Silurian and Old Red sandstone with igneous rocks rise to near 700 feet. From Tubbercurry to **Collooney** we continue along a vale of pastureland, with tracts of peat and some arable lands. The ground to the north rises boldly in a white rocky and wooded mountainous ridge—a continuation of the Ox Mountains (Quartzite, &c.), and beyond Collooney the railway follows the valley occupied by the Owenmore River, which further on enters Ballysodare Bay. Along this valley we pass cuttings in Drift and Carboniferous limestone and a belt of Quartzite, and from Ballysodare we cross a tract of limestone and Drift to **Sligo.**

III. MIDLAND GREAT WESTERN RAILWAY.

Dublin to Galway and Clifden.

MAP **34b** Proceeding from Broadstone Station, **Dublin,** we traverse an undulating tract of country formed of Carboniferous limestone extensively concealed by Drift. The granite hills of Dublin and Wicklow appear to the south soon after we leave the terminus. There are not many cuttings. The land is mostly in pasture, with a few fields under tillage and with some woodland; hedgerows and stone-fences are interspersed. Mounds and ridges of boulder gravel and sand (Eskers) and tracts of peat help to diversify the scenery. There is a station for Lucan (see page 166), and further on we pass Maynooth. We cross the river Boyne between Moy Valley and Hill of Down Stations, and reaching **Mullingar** we may get a glimpse of Loch Ennell (or Belvedere). The northern part of the indefinite Bog of Allen extends to this region. At **Athlone** we cross the Shannon, and proceed by Ballinasloe to **Athenry**, with distant views of the fine Old Red sandstone uplands of Slieve Aughty to the south. From **Athenry** to Oranmore and Galway we continue across the Drift-covered Carboniferous limestone.

Leaving **Galway** we cross the river whence issue the waters of Lough Corrib, with rugged scarps of limestone to the north, and through a wide tract of boggy alluvial ground. The land is divided into small enclosures, mostly of pasture-land, often with protruding bosses of limestone, or strewn with blocks of the rock, some of which have been utilized in the stone-fences. The railway skirts the boundary between the Carboniferous limestone and the granite rocks which form hilly ground on the south. Much of the land is irregular and hummocky, and there are many small loughs in the hollows, with banks of boulder drift and many tracts of peat. Beyond **Oughterard** we leave the limestone and enter a tract of granite and various schists, and thence onwards to Clifden we traverse a country of mountain, moor, and lough, with but few cultivated patches. The Quartzite mountains of Maamturk and the Twelve Pins (Bunnabeola) with Benbaun (2395 feet) rise to the north, separated by Lough Inagh, whose waters extend to the borders of the railway, and unite with Lough Glendalough near the Recess Hotel. At Ballynahinch there is another picturesque lough, and beyond we cross a wild country of moorland and many loughs to **Clifden.**

IV. GREAT NORTHERN RAILWAY (IRELAND).

Dublin to Belfast.

MAP **34a** Journeying from Amiens Street, **Dublin,** we cross a part of Dublin Bay to Clontarf, and traverse a long cutting in Drift and Carboniferous limestone. The bold headland of Howth (Cambrian) stands out to the east. Onwards to **Malahide** the route is through a tolerably flat country of pasture and arable land formed of Carboniferous limestone (shown in occasional cuttings), and with shallow cuttings in Drift We cross an inlet of the sea, fringed by Blown sand, to Donabate, and a tidal creek to the south of Rush and Lusk. Lambay Island, famed for its "porphyry," may be seen off the coast (see page 152). The railway traverses a tract of Yoredale shales and grits and another belt of limestone on to the Silurian and Ordovician rocks of **Balbriggan,** all the strata being much concealed by Drift. There is a fine cutting in Boulder Drift beyond Skerries, a name derived from the two rocky islets (Skerries), well seen off the coast; and we continue on Drift past the sandy bays of Balbriggan and Gormanston, skirting the coast as far as Layton, through a flat agricultural district. Thence we again enter a region of Carboniferous limestone, and at **Drogheda** we cross the head of the Boyne estuary, and traversing a mixed agricultural district pass through deep cuttings in Drift, and occasionally also of limestone. Beyond we cross a broad tract of Silurian rocks; the ground is more hilly but the cuttings are shallow, and the Drifts occur in great mounds. Silurian slaty rock is seen at **Dundalk,** and beyond we pass over the Castletown River, and across a flat country with mounds of Drift to Mount

Pleasant, where the Carboniferous limestone again occurs. Thence crossing a tract of slaty Silurian rocks we enter the mountainous region of Carlingford, with Clermont Carn (1674 feet), a rough craggy hill of granite (granophyre), to the east, and traverse a great vale bordered by heather-clad hills, with Slieve Gullion (1893 feet, granite and gabbro), on the west. From near **Newry** the dome-like Mourne Mountains (granite) appear at some distance away on the east. We leave the granite area at Goraghwood, and enter an agricultural region of Drift over Silurian rocks, with basalt at Poyntzpass and again at Portadown. Thence by **Lurgan** we traverse a tract of the Antrim basalts, cross Cretaceous rocks at **Moira,** and follow the fertile Lagan Valley over Trias and Drift by **Lisburn** to **Belfast.**

Greenore to Enniskillen.

MAP **34a** **Greenore,** situated on recent marine deposits and blown sand, at the entrance to Carlingford Lough, commands fine views of the Carlingford (1935 feet) and Mourne Mountains. The railway traverses Carboniferous limestone, largely concealed by Drift, to Dundalk Harbour; through a low lying agricultural tract, bordered on the north by rocky mountainous ground, and on the south by the broad sands of Dundalk Bay, exposed at low-tide from near Bush to Bellurgan. Further on the line traverses alluvial meadows, bordered by the sandy mud flats, which are seen at low-tide on the borders of Dundalk Harbour. Silurian rocks and Drift appear in the cutting at **Dundalk** Junction Station, and we traverse these rocks to near **Clones.** The Silurian gives but little character to the country, but the flaggy and slaty rocks are seen here and there in some of the cuttings, and occasionally in rocky hills. It is for the most part an agricultural region, the main features of which are due to the covering of Drift gravel and Boulder clay, with here and there peaty tracts, and a few picturesque loughs. These serve to diversify the country, which as far as **Castleblaney** is drained by the River Fane: westwards from Ballybay the streams drain into Upper Lough Erne.

After traversing a belt of Ordovician rocks at Newbliss, we cross the River Finn, on to the Drift-covered Carboniferous limestone series of **Clones.** Thence to Newtownbutler and beyond the Boulder clay is shown in several cuttings.

The mountainous Upper Carboniferous region of north-west Cavan, with Cuilcagh (2188 feet), is seen in the distance to the west. From Newtownbutler the railway runs through an undulating pastoral region with peaty tracts, east of Upper Lough Erne, to **Enniskillen.** This town is situated between the Upper and Lower Loughs, and we cross the connecting river as we proceed towards Sligo.

Enniskillen to Sligo (Sligo, Leitrim and Northern Counties' Railway).

MAP **34a** After leaving **Enniskillen** we cross a Drift-covered tract of pasture-land and peat, past the station for Florence Court (the seat of the Earl of Enniskillen), which lies a few miles to the south, on the borders of the mountainous uplands of Cavan and Leitrim. We approach these mountains at Belcoo, situated between Upper and Lower Lough Macnean, the latter with fine crags of limestone. The mountains are formed of the Upper Carboniferous rocks, and include Cuilcagh and the scarped Lackagh Hills, whence the Shannon takes its rise. We cross a tract of these Upper Carboniferous rocks covered with Drift and peat at Glenfarne, and soon afterwards pass again on to the Drift-covered Carboniferous limestone which extends in a vale to Collooney. The ground, mostly pasture, is varied with tracts of peat and Boulder clay, as well as Drift sand and gravel; and the limestone appears in occasional crags or knolls.

To the north, some of the Donegal mountains at times appear in view. Near **Manorhamilton** we cross the Bonet River and obtain views of the Sligo Mountains with Truskmore (2113 feet) formed of Carboniferous limestone. Further on we skirt the rugged and rocky mountainous ridge of Archæan quartzite, &c., which extends to **Collooney** and the Ox Mountains; and near Dromahair we may discern to the south-east the Upper Carboniferous mountain of Cashel (1377 feet), capped by coal-measures. Thence we soon reach Sligo (see p. 168).

Enniskillen to Bundoran.

MAP **34a** Leaving **Enniskillen** we pass over a Drift-covered tract of Lower Carboniferous rocks and Old Red sandstone, with many cuttings in Drift; a hilly country of grassland with several small loughs, and peaty tracts, diversified with woodlands. Through Bundoran Junction and Irvinestown, the foundation rock is Old Red sandstone, but at Kesh and thence to **Pettigo** we traverse the Lower Carboniferous sandstones and limestones, with cuttings in Drift and limestone, and peeps of Lower Lough Erne. Beyond Pettigo we cross a hilly and wooded tract, partly of schists, with crags of rock, peat and Boulder Drift, to Castlecaldwell; and skirting the lower end of Lough Erne, on Carboniferous limestone, past Belleek, we pass through cuttings of the rock and Drift, and near to the Falls of the Erne at **Ballyshannon.** Thence with fine views of the scarped Carboniferous hills to the south, we pass over a low undulating grass country of Drift and limestone, with craggy hills here and there, to **Bundoran.**

V. MIDLAND RAILWAY—NORTHERN COUNTIES SECTION.

Belfast to Antrim, Portrush and Londonderry.

MAP **34a** Leaving York Road Station, **Belfast,** we traverse the Triassic rocks and Drift, over a mixed agricultural district with shallow cuttings. From **Greenisland Junction** we pass across the outcrop of Cretaceous rocks on to the Basalt at Ballyclare Junction, and may observe spheroidal masses of the rock in the cuttings. At Templepatrick there are lime-works where an inlying tract of Chalk is quarried. Here also is a covering of basalt, with an intruded mass of rhyolite. Further on we cross areas of Drift gravel over basalt to **Antrim,** through a flat agricultural region to **Ballymena,** and passing an occasional cutting or quarry in basalt, we traverse a region of Drift mounds and peaty moors, to **Ballymoney, Coleraine** and **Portrush.**

From Ballymoney to Coleraine the railway runs along the valley of the Bann, crosses the river, and follows it to the sea-coast. As far as Downhill the foundation rock is basalt, beyond we pass near the basalt scarp of Magilligan which overlies Cretaceous, Liassic and Triassic rocks, and thence across Lower Carboniferous rocks and schists of ancient date, that are concealed largely by recent intakes and raised beaches, along the shores of Lough Foyle to **Londonderry.**

Greenisland to Larne.

MAP **34a** From **Greenisland** to Larne we continue along the flat agricultural vale of Triassic rocks and Drift that extends from Belfast to Carrickfergus, near which are salt-mines in the Keuper Marls. Thence the railway passes along the shore of Belfast Lough to Kilroot, traverses Cretaceous rocks and Basalt (in a tunnel) to Whitehead, and continues along the western side of Larne Lough, bordered by fine scarps of Keuper Marls, with overlying Rhætic Beds, Lias, Cretaceous rocks, and Basalt. On the opposite side of the Lough, Island Magee is connected with the mainland by the Drift-covered Red Marls. Near Whitehead the Marls are worked for brickmaking. By Magheramorne there is a large quarry where the chalk is worked for lime and whiting. **Larne** Harbour is situated on Raised Beach and Valley Drift.

LIST OF FIGURED FOSSILS.

The numerals indicate the Plates.

ACICULA LINEATA, *Drap.*, Gasteropod, 50
Pleistocene—Living (Britain).
Acrosalenia hemicidaroides, *Wright*, Ech., 41
Corallian.
—— spinosa, *Ag.*, Echinoid, 41
Kimeridge clay and Portland beds.
Actæon affinis, *Sow.*, Gasteropod, 44
Gault and Upper greensand.
Actinocrinus triacontadactylus, *Mill.*, Crinoid, 38
Carboniferous limestone.
Agnostus princeps, *Salt.*, Trilobite, 35
Menevian and Lingula flags.
Alethopteris lonchitica, *Schloth.*, Cycad-fern, 38
Coal measures and Culm measures.
Alveolina fusiformis, *Sow.*, Foraminifer, 47
Bracklesham beds.
Ammonites (Hoplites) Benettianus, *Sow.*, 45
Gault.
—— (Harpoceras) bifrons, *Brug.*, Ceph., 40
Upper Lias.
—— biplex, *see* A. Pallasianus.
—— (Coroniceras) Bucklandi, *Sow.*, 39
Lower lias.
—— (Keplerites) calloviensis, *Sow.*, 42
Kellaways beds and Oxford clay.
—— (Stephanoceras) communis, *Sow.*, 40
Upper lias.
—— (Cardioceras) cordatus, *Sow.*, 42
Oxford clay and Corallian.
—— (Hoplites) Deshayesi, *Leym.*, 44
Lower greensand.
—— (Perisphinctes) giganteus, *Sow.*, 43
Portland beds.
—— (Phylloceras) heterophyllus, *Sow.*, 40
Upper lias.
—— (Stephanoceras) Humphriesianus, *Sow.*, 40
Inferior oolite.
—— (Hoplites) interruptus, *Brong.*, 45
Gault and Red chalk.
—— (Cosmoceras) Jason, *Rein.*, 42
Oxford clay.
—— (Hoplites) lautus, *Sow.*, 45
Gault.
—— (Macrocephalites) macrocephalus, *Schloth.*, 41
Cornbrash and Kellaways beds.
—— (Acanthoceras) Mantelli, *Sow.*, 45.
Upper greensand and Lower chalk.
—— (Amaltheus) margaritatus, *Mont.*, 40
Middle lias.
—— (Acanthoceras) Martini, *d'Orb.*, 44
Lower greensand.
—— (Cadoceras) modiolaris, *Lhwyd.*, 42
Kellaways beds and Oxford clay.
—— (Hoplites) noricus, *Schloth.*, 44
Speeton clay.
—— (Arietites) obtusus, *Sow.*, 39
Lower lias.
Ammonites (Olcostephanus) Pallasianus, *d'Orb.* (Am. biplex, of authors, non. *Sow.*), 43
Kimeridge clay and Portland beds.
—— (Parkinsonia) Parkinsoni, *Sow.*, 40
Inferior oolite.
—— (Aspidoceras) perarmatus, *Sow.*, 42
Oxford clay and Corallian.
—— (Ægoceras) planicosta, *Sow.*, 39
Lower lias.
—— (Acanthoceras) rotomagensis, *Defr.*, 45
Lower chalk.
—— (Hildoceras) serpentinus, *Rein.*, 40
Upper lias.
—— (Olcostephanus) speetonensis, *Young and Bird*, 44
Speeton clay.
—— (Schloenbachia) varians, *Sow.*, 45
Upper greensand and Lower chalk.
—— —— varicosus, *Sow.*, 45
Gault and Upper greensand.
—— (Cardioceras) vertebralis, *Sow.*, 42
Oxford clay and Corallian.
Amplexus Sowerbyi, *Miller*, Coral, 38
Carboniferous limestone.
Ampyx nudus, *Murch.*, Trilobite, 35
Bala beds.
Ancilla fusiformis, *Sow.*, Gasteropod, 47
Bracklesham beds.
Ancyloceras gigas, *Sow.*, Cephalopod, 44
Lower greensand.
Ancyloceras tuberculatum, *Sow.*, 45
Gault and Upper greensand.
Ancylus fluviatilis, *Müll.*, Gasteropod, 50
Pleistocene—Living (Britain).
Annularia radiata, *Brong.*, Equisetum, 38
Culm measures and Coal measures.
Anodonta cygnea, *Linn.*, Bivalve, 50
Cromer Forest-bed—Living (Britain).
Apiocrinus Parkinsoni, *Schloth.*, Crinoid, 41
Great oolite, Bradford clay and Forest marble.
Aporrhais carinata, *Mant.*, Gasteropod, 44
Gault and Upper greensand.
—— Fittoni, *Forbes*, 44
Lower greensand.
—— pes-pelicani, *Linn.*, Gasteropod, 50
Coralline crag—Living (British Seas).
—— Sowerbyi, *Mant.*, 46
London clay and Headon beds.
Arachnophyllum Hennahi, *Lonsd.*, Coral, 37
Middle Devonian.
Aralia primigenia, *De la Harpe*, Plant, 47
Bagshot beds.
Arca biangula, *Lam.*, Bivalve, 47
Bracklesham and Headon beds.
Archæoniscus Brodiei, *M. Edw.*, Isopod, 43
Purbeck beds.
Asaphus tyrannus, *Murch.*, Trilobite, 35
Llandeilo beds.
Astarte borealis, *Chemn.*, Bivalve, 50
Norwich crag—Living (Northern Seas).

Astarte elegans, *Sow.*, 40
Inferior oolite.
—— elliptica, *Brown*, 50
Norwich crag—Living (Northern Seas).
—— Galeotti, *Nyst.*, 49
Coralline and Red crags.
—— Omalii, *Laj.*, 49
Coralline and Red crags.
—— tenera, *Morris*, 46
Thanet beds.
Asterophyllites, *see* Annularia.
Athyris pectinifera, *Sow.*, Brachiopod, 39
Magnesian limestone.
Atrypa reticularis, *Linn.*, Brachiopod, 36
Llandovery to Ludlow beds.
Aturia ziczac, *J. Sow.*, Cephalopod, 46
London clay and Bracklesham beds.
Avicula (Pteria) contorta, *Portl.*, Bivalve, 39
Rhætic beds.
—— (Oxytoma) costata, *Sow.*, 41
Great oolite to Cornbrash.
—— (Oxytoma) cygnipes, *Y. and B.*, 39
Lower and Middle lias.
—— (Pseudomonotis) echinata, *Sow.*, 41
Great oolite series, especially Cornbrash.
—— inæquivalvis, *Sow.*, 40
Lower lias to Inferior oolite.
—— *See also* Ptychopteria.
Aviculopecten sublobatus, *Phil.*, Bivalve, 38
Carboniferous limestone.

BALÆNOPTERA EMARGINATA, *Owen*, Cetacean Mammal (Earbone), 49
Red crag (Nodule bed).
Balanus crenatus, *Brug.*, Cirripede, 49
Coralline, Red and Norwich crags—Living (British Seas).
—— porcatus, *Da C.*, 49
Red and Norwich crags—Living (British Seas).
—— unguiformis, *Sow.*, 48
Headon, Bembridge and Hamstead beds.
Belemnitella mucronata, *Schloth.*, Ceph., 45
Upper chalk.
Belemnites abbreviatus, *Sow.*, Ceph., 42
Midford sands to Kimeridge clay, especially Corallian.
—— acuarius, *Schloth.*, 40
Midford sands.
—— canaliculatus, *Schloth.*, 40
Inferior oolite.
—— elongatus, *Sow.*, 39
Lower, Middle, and Upper lias.
—— hastatus, *Blainv.*, 42
Oxford clay.
—— minimus, *Lister*, 44
Gault, Upper greensand and Red chalk.
—— Oweni, *Pratt*, 42
Oxford clay, Corallian, and Kimeridge clay.
Bellerophon acutus, *Sow.*, Gasteropod, 36
Bala and Llandovery beds.
—— bilobatus, *Sow.*, 35
Llandovery and Wenlock beds.
—— costatus, *Sow.*, 38.
Carboniferous limestone.
—— dilatatus, *Sow.*, 36
Llandovery beds.
Bellerophon Urei, *Flem.*, 38
Upper Devonian and Carboniferous limestone.
Beryx, *see* Hoplopteryx.
Beyrichia complicata, *Salt.*, Ostracod, 36
Bala beds.
Bithynia tentaculata, *Linn.*, Gast., 50
Norwich crag, Cromer Forest bed—Living (Britain).
Bourguetia striata, *Sow.*, Gasteropod, 42
Inferior oolite and Corallian.
Brachymetopus ouralicus, *De Vern.*, Tril., 38
Carboniferous limestone.
Bronteus granulatus, *Goldf.* (B. flabellifer of some authors, non *Goldf.*), Tril., 37
Middle Devonian.
Buccinum Dalei, *J. Sow.*, Gasteropod, 49
Coralline Crag—Living (British Seas).
—— undatum, *Linn.*, 50
Coralline crag—Living (British Seas).
Bulimus ellipticus, *Sow.*, Gasteropod, 48
Headon, Osborne and Bembridge beds.

CALAMITES CANNÆFORMIS, *Schloth.*, Equisetum, 38
Coal measures.
Calamophyllia (Eunomia) radiata, *Lamx.*, Coral, 41
Great oolite.
—— Stokesi, *E. and H.*, Coral, 42
Corallian.
Calceola sandalina, *Lam.*, Coral, 37
Middle Devonian.
Calymene Blumenbachii, *Brong.*, Tril., 36
Bala to Ludlow beds.
Calyptræa chinensis, *Linn*, Gast., 49
Coralline crag—Living (British Seas).
Camarophoria Schlotheimi, *von Buch*, Brachiopod, 39
Magnesian limestone.
Capulus ungaricus, *Linn.*, Gasteropod, 49
Coralline crag—Living (British Seas).
Carbonicola aquilina, *Sow.*, Bivalve, 38
Coal measures.
Carcharodon megalodon, *Ag.*, Fish (tooth), 49
Nodule-bed at base of Red crag
Cardinia Listeri, *Sow.*, Bivalve, 39
Lower lias.
Cardita planicosta, *Lam.*, Bivalve, 47
Bracklesham beds.
—— scalaris, *Leathes*. 49
Coralline and Red crags.
—— senilis, *Lam.*, 49
Coralline and Red crags.
—— tenuicosta, *Sow.*, 44
Gault and Upper greensand.
Cardium cognatum, *Phil.*, Bivalve, 41
Inferior and Great oolite series.
—— (Protocardium) dissimile, *Sow.*, 43
Portland beds.
—— edule, *Linn.*, 50
Coralline crag—Living (British Seas).
—— Laytoni, *Morris*, 46
Woolwich beds.
—— porulosum, *Brand*, 47
Bracklesham, Barton and Headon beds.
—— (Protocardium) rhæticum, *Merian*, 39
Rhætic beds.

Cardium (Protocardium) stratulum, *Sow.*, 43
Kimeridge clay.
—— *See also* Protocardium.
Carychium minimum, *Müll.*, Gasteropod, 50
Norwich crag, Cromer Forest bed—Living (Britain).
Cassidaria bicatenata, *J. Sow.*, Gast., 49
Coralline and Red crags.
Cellepora coronopus, *S. Wood*, Bryozoan, 49
Coralline crag.
Cephalaspis Lyelli, *Ag.*, Fish, 37
Lower old red sandstone.
Cephalites Benettiæ, *Mant.*, Sponge, 45
Middle and Upper chalk.
Cerithium concavum, *Sow.*, Gasteropod, 48
Headon Beds.
—— mutabile, *Lam.*, 48
Headon, Bembridge and Hamstead beds.
—— plicatum, *Lam.*, 48
Headon and Hamstead beds.
—— portlandicum, *Sow.* (cast), 43.
Portland beds.
—— pseudo-cinctum, *d'Orb.*, 48
Headon and Hamstead beds.
—— Sedgwicki, *Morris*, 48
Hamstead beds.
—— tricinctum, *Broc.*, 49
Coralline, Red and Norwich crags.
—— ventricosum, *Sow.*, 48
Headon beds.
Ceromya concentrica, *Sow.*, Bivalve, 41
Inferior and Great oolite series.
Chama squamosa, *Brand.*, Bivalve, 47
Barton beds.
Chara medicaginula, *Brongn.*, Plant, 48
Bembridge beds.
Chemnitzia (Pseudomelania) Heddingtonensis, *Sow.*, Gasteropod, 42
Corallian.
Chonetes lata, *von Buch.*, Brachiopod, 36
Ludlow beds.
Cidaris florigemma, *Phil.*, Echinoid, 42
Corallian.
—— Fowleri, *Wright*, 40
Inferior oolite.
Clausilia bidentata, *Ström.*, 50
Pleistocene—Living (Britain).
—— laminata, *Mont.*, Gasteropod, 50
Pleistocene—Living (Britain).
—— Rolphii, *Gray.*, 56
Pleistocene—Living (Britain).
Clymenia undulata, *Münst.*, Cephalopod, 37
Upper Devonian.
Clypeus Ploti, *Klein.*, Echinoid, 40
Inferior oolite.
Cœlonautilus cariniferus, Cephalopod, *Sow.*, 38
Carboniferous limestone.
Collyrites ringens, *Ag.*, Echinoid, 40
Inferior oolite.
Columbella sulcata, *J. Sow.*, Gasteropod, 49
Coralline and Red crags.
Conocardium aliforme, *Sow.*, Bivalve, 38
Devonian and Carboniferous limestone.
Conocoryphe bucephala, *Belt.*, Trilobite, 35
Lingula flags.
Conorbis dormitor, *Brand.*, Gasteropod, 47
Barton clay and Headon beds.
Conularia quadrisulcata, *Sow.*, Pteropod, 38
Coal measures.
Conus deperditus, *Brug.*, Gasteropod, 47
Bracklesham beds.
Corbicula fluminalis, *Müll.*, 50
Red crag to Pleistocene valley-gravel—Living (Asia and Africa).
Corbis corrugata, *Sow.*, Bivalve, 44
Lower greensand
Corbula alata, *J. Sow.*, Bivalve, 48
Purbeck and Wealden beds.
—— globosa, *Sow.*, 46
London clay, Bracklesham and Barton beds.
—— Lamarcki, *Desh.*, 47
Bracklesham and Barton beds.
—— pisum, *Sow.*, 48
Bracklesham, Barton, Headon, Bembridge and Hamstead beds.
—— vectensis, *Forbes*, 48
Hamstead beds.
Cottaldia Benettiæ, *Koenig*, Echinoid, 44
Upper greensand and Lower chalk.
Crania Parisiensis, *Defr.*, Brachiopod, 45
Upper chalk.
Crassatella sulcata, *Brand.*, Bivalve, 47
Bracklesham and Barton beds.
Crioceras Duvali, *Lév.*, Cephalopod, 44
Speeton beds.
Cucullæa decussata, *Park.*, Bivalve, 46
Thanet beds and London clay.
—— glabra, *Sow.*, 44
Gault and Upper greensand.
—— unilateralis, *Sow.*, 37
Upper Devonian.
Cyathocrinus calcaratus, *Phil.*, Crinoid, 38
Carboniferous limestone.
Cyathophyllum cæspitosum, *Goldf.*, Coral, 37
Middle Devonian.
—— truncatum, *Linn.*, 36
Wenlock and Ludlow beds.
Cyclas Bristovii, *Forbes*, Bivalve, 48
Hamstead beds.
Cyclocyathus Fittoni, *M. Edw.*, Coral, 44
Gault.
Cyclotus cinctus, *Edw.*, Gasteropod, 48
Bembridge beds.
Cyphosoma granulosum, *Goldf.*, Echinoid, 45
Middle and Upper chalk.
Cypræa Bowerbankii, *Sow.*, Gasteropod, 47
London clay and Bracklesham beds.
—— Europæa, *Mont.*, 49
Coralline and red crags—Living (British Seas).
Cypridea granulosa, *Sow.*, Ostracod, 43
Purbeck beds.
—— spinigera, *Sow.*, 43
Oxford clay, Wealden and Hamstead beds.
—— tuberculata, *Sow.*, 43
Purbeck and Wealden beds.
—— Valdensis, *Fitton*, 43
Purbeck and Wealden beds.
Cyprina angulata, *Flem.*, Bivalve, 44
Gault and Upper greensand.
—— islandica, *Linn.*, 49
Coralline crag—Living (British Seas).
—— Morrisi, *Sow.*, 46
Thanet beds and London clay.
—— rustica, *J. Sow.*, 49
Coralline and Red crags.
Cyrena cordata, *Morris*, Bivalve, 46
Woolwich beds.

Cyrena cuneiformis, *Sow.*, 46
Woolwich beds.
—— elongata, *J. Sow.*, 43
Purbeck and Wealden beds.
—— media, *Sow.*, 43
Purbeck and Wealden beds.
—— obovata, *Sow.* 48
Headon, Osborne, and Bembridge beds.
—— obtusa, *Forbes*, 48
Bembridge beds.
—— parva, *J. Sow.*, 43
Purbeck beds.
—— pulchra, *Sow.*, 48
Headon and Bembridge beds.
—— semistriata, *Desh.*, 48
Bembridge and Hamstead beds.
Cystiphyllum vesiculosum, *Goldf.*, Coral, 37
Middle Devonian
Cytherea incrassata, *Desh.*, Bivalve, 48
Barton, Headon and Bembridge beds.
—— Lyelli, *Forbes*, 48
Hamstead beds.
—— orbicularis, *Morris*, 46
Thanet and Woolwich beds, and London clay.
—— plana, *Sow.*, 44
Upper greensand.
—— trigonula, *Desh.*, 47
Bracklesham beds.

DAVIA NAVICULA, *Sow.*, Brachiopod, 36
Wenlock and Ludlow beds.
Dentalium decussatum, *Sow.*, Gast., 44
Gault.
Diceras Lonsdalei, *Sow.*, Bivalve (cast), 44
Lower greensand.
Didymograptus Murchisoni, *Bœck.*, Graptolite, 35
Arenig and Llandeilo beds.
Diplodonta rotundata, *Mont.*, Bivalve, 49
Coralline and Red crags—Living (British Seas).
Diplograptus pristis, *His.*, Graptolite, 35
Bala beds.
Ditrupa plana, *Sow.*, Annelide, 46
London clay, Bracklesham and Barton beds.
Doryderma ramosum, *Mant.*, Sponge, 45
Middle and Upper chalk.

ECHINOBRISSUS CLUNICULARIS, *Lhwyd.*, Echinoid, 41
Great oolite series—especially Cornbrash.
—— dimidiatus, *Phil.*, 42
Corallian.
—— orbicularis, *Phil.*, 41
Cornbrash.
Echinoconus, *see* Galerites.
Echinocorys scutatus, *Leske*, Echinoid, 45
Middle and Upper chalk.
Echinoencrinus armatus, *Forbes*, Cystidean, 36
Wenlock beds.
Echinosphærites aurantium, *Gyll.*, Cystidean, 35
Bala beds.
—— Balthicus, *Eichw.*, 35
Bala beds.

Emarginula fissura, *Linn.*, Gasteropod, 49
Coralline and Red Crags—Living (British Seas).
Exogyra sinuata, *Sow.*, Bivalve, 44
Lower greensand and Speeton beds.
Encrinurus punctatus, *Brün.*, Trilobite, 36
Llandovery to Ludlow beds.
Entomis serratostriata, *Sandb.*, Ostracod, 37
Upper Devonian.
Equisetites Lyellii, *Mant.*, Equisetum, 43
Purbeck and Wealden.
Eryon Barrovensis, *McCoy*, Macruran Crustacean, 39
Lower Lias.
Eschara monilifera, *M. Edw.*, Bryozoan, 49
Coralline and Red Crags.
Estheria elliptica, *Dunk.*, Phyllopod, 43
Purbeck and Wealden beds.
—— membranacea, *Pacht.*, 37
Old red sandstone.
—— minuta, *Alberti*, 39
Keuper.
—— striata, *Münst.*, 38
Carboniferous limestone series.
Etyus Martini, *Mant.*, Brachyuran Crust., 45
Gault.
Eulima glabella, *S. Wood.*, Gasteropod, 49
Coralline Crag—Living (Southern Seas).
Eunomia, *see* Calamophyllia.
Euomphalus pentangulatus, *Sow.*, Gast., 38
Carboniferous limestone.
Eurypterus pygmæus, *Salt.*, Eurypterid Crustacean, 36
Ludlow beds.
Exogyra virgula, *Defr.*, Bivalve, 43
Kimeridge clay.
Extracrinus (Pentacrinus) Briareus, *Mill.* (E. britannicus, *Schloth.*), Crinoid, 39
Lower lias.

FASCICULARIA AURANTIUM, *M. Edw.*, Bryozoan, 49
Coralline and Red crags.
Favosites fibrosa, *Goldf.*, Coral, 36
Ordovician and Silurian.
—— polymorpha, *Goldf.*, 37
Silurian to Middle Devonian.
Fenestella retiformis, *Schloth.*, Bryozoan, 39
Magnesian limestone.
Ficus Forbesii, *De la Harpe*, Plant, 47
Bagshot beds.
Fusus longævus, *Brand*, Gasteropod, 47
Bracklesham, Barton and Headon beds.
—— porrectus, *Brand*, 47
Barton clay.

GALEOCERDO LATIDENS, *Ag.*, Fish, 47
Bracklesham beds.
Galerites albogalerus, *Leske*, Echinoid, 45
Upper chalk.
Gastrioceras, *see* Goniatites.
Gervillia acuta, *Sow.*, Bivalve, 42
Great oolite series.
—— anceps, *Desh.*, 44
Lower greensand.
—— aviculoides, *Sow.*, 42
Cornbrash to Corallian.

Gervillia tortuosa, *Sow.*, 40
Inferior oolite.
Glandina costellata, *Sow.*, Gasteropod, 48
Headon and Bembridge beds.
Glyphioceras, *see* Goniatites.
Gomphoceras pyriforme, *Sow.*, Ceph., 36
Ludlow beds.
Goniatites (Gastrioceras) Listeri, *Mart.*, Cephalopod, 38
Carboniferous limestone series.
—— (Glyphioceras), sphericus, *Mart.*, 38
Carboniferous limestone series.
Goniomya V-scripta, *Sow.* 42
Cornbrash to Portland beds.
Granatocrinus orbicularis, *Sow.*, Blastoid Echinoderm, 38
Carboniferous limestone.
Griffithides globiceps, *Phil.*, Trilobite, 38
Carboniferous limestone.
Gryphæa arcuata, *Lam.*, Bivalve, 39
Lower lias.
—— dilatata, *Sow*, 42
Oxford clay and Corallian.
Gyroceras tredecimale, *Phil.*, Ceph., 37
Middle Devonian.

HALYSITES CATENULARIA, *Linn.*, Coral, 36
Ordovician and Silurian.
Hamites, *see* Helicoceras.
Harpes macrocephalus, *Goldf.*, Trilobite, 37
Middle Devonian.
Helicella virgata, *Da Costa*, Gasteropod, 50
Pleistocene—Living.
Helicoceras rotundum, *Sow.*, Cephalopod, 45
Gault and Upper greensand.
Helicogona lapicida, *Linn.*, Gasteropod, 50
Pleistocene—Living.
Helix D'Urbani, *Edw.*, Gasteropod, 48
Bembridge beds.
—— nemoralis, *Linn.*, 50
Cromer Forest bed—Living (Britain).
Hemicidaris intermedia, *Flem.*, Echinoid, 42
Corallian.
Hippopodium ponderosum, *Sow.*, Bivalve, 39
Lower and Middle lias.
Holectypus hemisphericus, *Ag.*, Ech., 40
Inferior oolite.
Holoptychius nobilissimus, *Ag.*, Fish, 37
Upper old red sandstone.
Homalonotus armatus, *Burm.*, Trilobite, 37
Lower Devonian.
—— delphinocephalus, *Green*, 36
Wenlock and Ludlow beds.
Hoploparia gammaroides, *McCoy*, Macruran Crustacean, 46
London clay.
—— longimana, *Sow.*, Macruran Crust., 45
Gault and Upper greensand.
Hoplopteryx lewesiensis, *Mant.*, Fish, 45
Lower, Middle and Upper chalk.
Hybodus reticulatus, *Ag.*, 39
Rhætic beds and Lower lias.
Hymenocaris vermicauda, *Salt.*, Phyllocarid Crustacean, 35
Lingula flags.
Hyolithes (Theca) triangularis, *Portl.*, Pteropod, 35
Bala beds.

ICHTHYOSAURUS COMMUNIS, *Conyb.*, Reptile, 39
Lower lias.
Iguanodon Mantelli, *Meyer*, Reptile (tooth), 43
Purbeck and Wealden beds.
Illænus Davisii, *Salt.*, Trilobite, 35
Bala beds.
Inoceramus concentricus, *Park.*, Bivalve, 44
Gault and Upper greensand.
—— mytiloides, *Mant.*, 45
Lower, Middle and Upper chalk.
—— sulcatus, *Park.*, 44
Gault and Upper greensand.
Isastræa explanata, *Goldf.*, Coral, 42
Corallian.
—— oblonga, *Flem.*, 43
Portland beds.
Isocardia minima, *Sow.*, Bivalve, 41
Great oolite series to Kimeridge clay.

JAMINIA CYLINDRACEA, *Da Costa*, Gast., 50
Norwich crag—Living (Britain).

KIRKBYA PERMIANA, *Jones*, Ostracod, 39
Magnesian limestone.

LAMNA APPENDICULATA, *Ag.*, Fish (tooth), 45
Gault, Upper greensand and Chalk.
—— *See also* Odontaspis.
Laurus Jovis, *Unger*, Plant, 47
Bagshot beds.
Leda (Nuculana) oblongoides, *S. Wood.*, Bivalve, 49
Red and Norwich crags.
Leda ovum, *Sow.*, 40
Upper lias.
Lepidodendron elegans, *Brong.*, Lycopod, 38
Coal measures.
—— Sternbergi, *Brong.*, 38
Coal measures.
Lima duplicata, *Sow.*, Bivalve, 42
Lias to Portland beds.
—— gigantea, *Sow.*, 39
Lower lias.
—— parallela, *d'Orb.*, 44
Gault and Upper greensand.
—— pectiniformis, *Schloth.*, 40
Inferior oolite to Corallian.
—— rigida, *Sow.*, 42
Inferior oolite to Corallian.
Limnæa auricularia, *Linn.*, Gasteropod, 50
Norwich crag—Living (Britain).
—— longiscata, *Sow.*, 48
Headon, Osborne and Bembridge beds.
—— palustris, *Müll.*, 50
Red and Norwich crags, Cromer Forest bed—Living (Britain).
—— truncatula, *Müll.*, 50
Red and Norwich crags, Cromer Forest bed—Living (Britain).
Lingula Lewisii, *Sow.*, Brachiopod, 36
Wenlock and Ludlow beds.
Lingulella Davisi, *McCoy*, Brachiopod, 35
Lingula flags and Tremadoc beds.
Litharæa Websteri, *Bowerb.*, Coral, 47
Bracklesham beds.

Lithostrotion basaltiforme, *Phil.*, Coral, 38
Carboniferous limestone.
Littorina littorea, *Linn.*, Gasteropod, 50
Red crag—Living (British Seas).
Lituites, *see* Trochoceras.
Loripes divaricatus, *Linn.*, Bivalve, 49
Red crag—Living (British Seas).
Lucina borealis, *Linn.*, Bivalve, 49
Coralline crag—Living (British Seas).
—— Portlandica, *Sow.*, 43
Portland beds.

MACTRA ARCUATA, *J. Sow.*, Bivalve, 49
Coralline, Red and Norwich crags.
—— ovalis, *J. Sow.*, 49
Red and Norwich crags—Living (British Seas).
—— subtruncata, *Da C.*, 49
Coralline and Norwich crags—Living (British Seas).
Magas pumilus, *Sow.*, Brachiopod, 45
Lower and Upper chalk.
Mantellia nidiformis, *Brongn.*, Cycad, 43
Purbeck beds.
Marsupites testudinarius, *Schloth.*, Crinoid, 45
Upper chalk.
Mastodon arvernensis, *Cr. and Job.*, Mammal (tooth), 49
Red and Norwich crags.
Mastodonsaurus giganteus, *Miall*, Amphibian, 39
Keuper.
Megalodon cucullatus, *Sow.*, Bivalve, 37
Middle Devonian.
Megalosaurus Bucklandi, *von Meyer*, Reptile (tooth), 41
Inferior oolite to Kimeridge clay.
Melampus pyramidalis, *J. Sow.*, Gast., 49
Red and Norwich crags, Cromer Forest bed.
Melania costata, *Sow.*, Gasteropod, 48
Barton beds.
—— fasciata, *Sow.*, 48
Headon, Bembridge and Hamstead beds.
—— inquinata, *Defr.*, 46
Woolwich beds.
—— muricata, *Wood*, 48
Headon, Osborne, Bembridge and Hamstead beds.
—— turritissima, *Forbes*, 48
Bembridge and Hamstead beds.
Melanopsis carinata, *Sow.*, Gasteropod, 48
Headon, Osborne, Bembridge and Hamstead beds.
—— fusiformis, *Sow.*, 48
Headon and Bembridge beds.
Metacypris Fittoni, *Mant.*, Ostracod, 43
Wealden.
Meyeria Vectensis, *Bell*, Macruran Crust., 44
Lower greensand.
Micraster cor-anguinum, *Klein*, Ech., 45
Upper chalk.
Modiola bipartita, *Sow.*, Bivalve, 42
Great oolite to Portland beds.
—— gibbosa, *Sow.*, 41
Inferior and Great oolite series.
—— modiolus, *Linn.*, 49
Red and Norwich crags—Living (British Seas).
Modiola Prestwichi, *Morris*, 48
Hamstead beds.
—— Sowerbyana, *d'Orb.*, 40
Inferior and Great oolite series.
Monograptus priodon, *Bronn.*, Graptolite, 36
Llandovery and Wenlock beds.
Murchisonia scalaris, *Salt.*, Gasteropod, 35
Bala beds.
—— turbinata, *Schloth.*, 37
Middle Devonian.
Murex asper, *Brand*, Gasteropod, 47
Bracklesham beds and Barton clay.
—— erinaceus, *Linn.*, 50
Red crag—Living (British Seas).
—— spinulosus, *Desh.*, 46
London clay.
Myacites decurtatus, *Phil.*, Bivalve, 41
Inferior oolite to Corallian.
—— oblatus, *Sow.*, 42
Corallian.
Mya truncata, *Linn.*, Bivalve, 50
Coralline crag—Living (British Seas).
Myliobatis toliapica, *Ag.*, Fish, 47
London clay, Bracklesham beds, and Barton clay.
Myophoria postera, *Quenst.*, Bivalve, 39
Rhætic beds.
Mytilus affinis, *Sow.*, Bivalve, 48
Headon and Bembridge beds.
—— edulis, *Linn.*, 50
Coralline Crag—Living (British Seas).

NASSA GRANULATA, *J. Sow.*, 49
Coralline and Red crags.
—— reticosa, *J. Sow.*, 49
Red and Norwich crags.
Nassa reticulata, *Linn.*, 50
Pleistocene—Living (British Seas).
Natica catena, *Da. C.*, Gasteropod, 49
Red crag—Living (British Seas).
—— clausa, *Brod. and Sow.*, 50
Red crag—Living (British Seas).
—— elegans, *Sow.*, 43
Portland beds.
—— Genti, *Sow.*, 44
Gault and Upper greensand.
—— Michelini, *d'Arch.*, 41
Inferior and Great oolite.
—— millepunctata, *Lam.*, 49
Coralline and Red crags—Living (Southern Seas).
Nautilus centralis, *Sow.*, Cephalopod, 46
London clay.
—— hexagonus, *Sow.*, 42
Oxford clay and Corallian.
—— plicatus, *Sow.*, 44
Lower greensand.
—— truncatus, *Sow.*, 39
Lower and Middle lias.
Neithea, *see* Pecten.
Nemacanthus monilifer, *Ag.*, Fish, 39
Rhætic beds.
Nematura (Stenothyra) parvula, *Desh.*, Gasteropod, 48
Headon and Hamstead beds.
Nerinæa Goodhalli, *Sow.*, Gasteropod, 42
Corallian.
Neritina concava, *Sow.*, Gasteropod, 48
Headon, Bembridge and Hamstead beds.

Neritina tristis, *Forbes*, 48
Hamstead beds.
Neritoma sinuosa, *Sow.*, Gasteropod, 43
Portland beds.
Neuropteris gigantea, *Sternb.*, Cycad-fern, 38
Coal measures.
Nilssonia compta, *Phil.*, Cycad, 40
Inferior oolite.
Nucula Bowerbanki, *Sow.*, Bivalve, 46
Thanet beds and London clay.
—— Cobboldiæ, *J. Sow.*, 49
Red and Norwich crags, Cromer Forest bed.
—— Headonensis, *Forbes*, 48
Headon beds.
—— nucleus, *Linn.*, 49
Coralline and Red crags—Living (British Seas).
—— ovata, *Sow.*, 44
Gault and Upper greensand.
—— pectinata, *Sow.*, 44
Gault and Upper greensand.
—— tenuis, *Mont.*, 50
Red and Norwich crags—Living (British Seas).
Nuculana amygdaloides, *Sow.*, Bivalve, 46
London clay.
—— *See also* Leda.
Nummulites lævigatus, *Brug.*, Foram., 47
Bracklesham beds.
—— variolarius, *Lam.*, 47
Bracklesham beds.
Nymphaster Coombei, *Forbes*, Asteroid, 45
Lower, Middle, and Upper chalk.

ODONTASPIS ELEGANS, *Ag.*, Fish, 47
London clay and Bracklesham beds.
Offaster pillula, *Lam.*, Echinoid, 45
Upper chalk.
Ogygia Buchii, *Brong.*, Trilobite, 35
Llandeilo beds.
Olenellus Callavei, *Lapw.*, Trilobite, 35
Lower Cambrian.
Olenus alatus, *Boeck.*, Trilobite, 35
Lingula flags.
—— gibbosus, *Wahlb.*, 35
Lingula flags.
—— micrurus, *Salt.*, 35
Lingula flags.
—— scarabœoides, *Wahl.*, 35
Lingula flags.
Oliva Branderi, *Sow*, Gasteropod, 47
Barton clay
Omphyma turbinatum, *Linn.*, Coral, 36
Wenlock beds.
Onchus tenuistriatus, *Ag.*, Fish, 36
Ludlow beds and Lower old red sandstone.
Ophiura Wetherelli, *Forbes*, Brittle Star, 46
London clay.
Orthis calligramma, *Dalm.*, Brachiopod, 35
Llandeilo to Wenlock beds.
—— lenticularis, *Dalm.*, Brachiopod, 35
Arenig and Llandeilo beds.
—— vespertilio, *Sow.*, Brachiopod, 35
Llandeilo to Llandovery beds.
Orthoceras annulatum, *Sow.*, Ceph., 36
Wenlock and Lower Ludlow beds.
—— filosum, *Sow.*, 36
Ludlow beds.
Orthoceras tenuicinctum, *Portl.*, 36
Wenlock beds.
—— vagans, *Salt*, 35
Bala beds.
Ostrea bellovacina, *Lam.*, Bivalve, 46
Woolwich beds.
—— callifera, *Lam.*, 48
Hamstead beds.
—— deltoidea, *Sow.*, 43
Kimeridge clay.
—— distorta, *Sow.*, 43
Purbeck and Wealden beds.
—— edulis, *Linn.*, 50
Red and Norwich crags—Living (British Seas).
—— flabelloides, *Lam.*, 41
Inferior oolite to Corallian, especially Cornbrash.
—— (Alectryonia) flabellula, *Lam.*, 47
Bracklesham, Barton and Headon beds.
—— frons, *Park*, 45
Gault, Upper greensand and Lower chalk.
—— gregaria, *Sow.*, 42
Great oolite to Kimeridge clay.
—— Sowerbyi, *Lyc.*, 41
Great oolite series.
—— Vectensis, *Forbes*, 48
Bembridge beds.
—— velata, *Wood*, 48
Headon beds.
Otodus obliquus, *Ag.*, Fish, 46
London clay.

PALÆOCORYSTES STOKESII, *Mant.*, Brachyuran Crustacean, 45
Gault, Lower chalk.
Palæoniscus comptus, *Ag.*, Fish, 39
Permian.
Paludestrina marginata, *Mich.*, Gast., 50
Cromer Forest bed—Pleistocene.
Paludina (Viviparus) fluviorum, *Sow.*, Gasteropod, 43
Wealden.
—— —— lenta, *Sow.*, 48
Headon, Osborne, Bembridge and Hamstead beds.
—— —— sussexiensis, *J. Sow*, 43
Purbeck and Wealden beds.
Panopæa Faujasii, *Men. de la G.*, Bivalve, 49
Coralline and Red crags—Living (Southern Seas).
—— intermedia, *Sow.*, 46
London clay and Barton clay.
—— (Mya) minor, *Forbes*, 48
Bembridge and Hamstead beds.
—— Norvegica, *Speng.*, 50
Red and Norwich crags—Living (British Seas).
Parabolina spinulosa, *Wahl.*, Trilobite, 35
Lingula flags.
Paracyathus caryophyllus, *Lam.*, Coral, 46
London clay.
Paradoxides Davidis, *Salt.*, Trilobite, 35
Menevian.
Parasmilia centralis, *Mant.*, Coral, 45
Middle and Upper chalk.
Pecten arcuatus, *Sow.*, Bivalve, 41
Inferior oolite to Kimeridge clay.
Pecten asper, *Lam.*, 44
Upper greensand and Lower chalk.

Pecten Beaveri, *Sow.*, 45
Gault, Lower and Middle chalk.
—— cinctus, *Sow.*, 44
Speeton beds.
—— corneus, *Sow.*, 47
Bracklesham and Barton beds.
—— Islandicus, *Müll.*, 50
Pleistocene—Living (Northern Seas).
—— lamellosus, *Sow.*, 43
Portland beds.
—— maximus, *Linn.*, 50
Coralline and Red crags—Living (British Seas).
—— opercularis, *Linn.*, 49
Coralline, Red and Norwich crags—Living (British Seas).
—— orbicularis, *Sow.*, 44
Gault, Upper greensand and Lower chalk.
—— pusio, *Penn.*, 49
Coralline and Red crags—Living (British Seas).
—— (Neithea) quinquecostatus, *Sow.*, 44
Gault, Upper greensand and Chalk.
—— vagans, *Sow.*, 41
Great oolite series to Oxford clay.
—— valoniensis, *Defr.*, 39
Rhætic beds.
Pectunculus brevirostris, *Sow.*, Bivalve, 46
London clay.
—— decussatus, *Sow.*, 46
London clay.
—— glycimeris, *Linn.*, 49
Coralline Red and Norwich crags—Living (British Seas).
—— pulvinatus, *Lam.*, 47
Bracklesham beds.
—— terebratularis, *Lam.*, 46
Thanet beds.
Peltastes Wrighti, *Desor.*, Echinoid, 44
Lower greensand.
Pentacrinus, *see* Extracrinus.
Pentamerus Knightii, *Sow.*, Brachiopod, 36
Ludlow beds.
—— oblongus, *Sow.*, 36
Llandovery beds.
Pentremites, *see* Granatocrinus.
Perna Mulleti, *Desh.*, Bivalve, 44
Lower greensand.
—— quadrata, *Sow.*, 42
Inferior oolite to Corallian.
Petraia bina, *Lonsd.*, Coral, 36
Bala to Ludlow beds.
Phacops caudatus, *Brong.*, Trilobite, 36
Wenlock and Ludlow beds.
—— Downingiæ, *Murch.*, 36
Wenlock and Ludlow beds.
—— latifrons, *Bronn.*, Trilobite, 37
Middle and Upper Devonian.
Phascolotherium Bucklandi, *Brod.*, Mammal, 41
Stonesfield slate.
Phillipsia derbiensis, *Mart.*, Trilobite, 38
Carboniferous limestone.
—— pustulata, *Schloth.*, 38
Carboniferous limestone.
Phlebopteris polypodioides, *Brongn.*, Fern, 40
Inferior oolite.
Pholadomya acuticosta, *Sow.*, Bivalve, 41
Great oolite series.
Pholadomya æqualis, *Sow.*, 42
Corallian and Kimeridge clay.
—— cuneata, *Sow.*, 46
Thanet beds.
—— fidicula, *Sow.*, 40
Inferior oolite series.
—— lyrata, *Sow.*, 41
Great oolite series.
—— Murchisoni, *Sow.*, 41
Great oolite series.
Pholas crispata, *Linn.*, 50
Red and Norwich crags—Living (British Seas).
Phorus, *see* Xenophora.
Phragmoceras ventricosum, *Sow.*, Ceph., 36
Llandovery and Wenlock beds.
Physa Bristovii, *Forbes*, Gasteropod, 43
Purbeck beds.
—— fontinalis, *Linn.*, Gasteropod, 50
Cromer Forest bed—Living (Britain).
Pinna affinis, *Sow.*, Bivalve, 46
London clay
Pitharella Rickmani, *Edw.*, Gasteropod, 46
Woolwich beds.
Planorbis corneus, *Linn.*, Gasteropod, 50
Red and Norwich crags, Cromer Forest bed—Living (Britain).
—— euomphalus, *Sow.*, 48
Headon, Osborne and Bembridge beds.
—— obtusus, *Sow.*, Gasteropod, 48
Headon, Osborne, Bembridge and Hamstead beds.
—— umbilicatus, *Müll.*, 50
Pleistocene—Living (Britain).
—— vortex, *Linn.*, 50
Cromer Forest bed—Living (Britain).
Platysomus striatus, *Ag.*, Fish, 39
Magnesian limestone.
Plesiosaurus dolichodirus, *Conyb.*, Reptile, 39
Lower lias.
Pleurodictyum problematicum, *Goldf.*, Coral, 37
Lower and middle Devonian.
Pleuromya plicata, *Sow.*, Bivalve, 44
Lower greensand, Gault and Upper greensand.
Pleurotoma acuminata, *Sow.*, Gast., 46
London clay.
—— attenuata, *Sow.*, 47
Bracklesham beds.
Pleurotomaria antrina, *Schloth.*, Gast., 39
Magnesian limestone.
—— carinata, *Sow.*, 38
Carboniferous limestone.
—— ornata, *Sow.*, 40
Inferior oolite.
—— reticulata, *Sow.*, 43
Oxford clay to Kimeridge clay.
Plicatula pectinoides, *Sow.*, Bivalve, 44
Gault and Upper greensand.
Pollicipes glaber, *Roem.*, Cirripede, 45
Chalk.
Posidonomya Becheri, *Goldf.*, Bivalve, 38
Carboniferous.
Potamides funatus, *Sow.*, Gasteropod, 46
Woolwich beds.
Potomomya plana, *Sow.*, Bivalve, 48
Headon and Osborne beds.

Prestwichia rotundata, *H. Woodw.*, Xiphosuran Crustacean, 38
Coal measures.
Productus giganteus, *Mart.*, Brachiopod, 38
Carboniferous limestone.
—— horridus, *Sow.*, 39
Magnesian limestone.
—— Martini, *Sow*, 38
Carboniferous limestone.
—— punctatus, *Mart.*, 38
Carboniferous limestone.
—— scabriculus, *Mart.*, 38
Upper Devonian and Carboniferous limestone series.
Protocardium Hillanum, *Sow.*, 44
Upper greensand and Lower chalk.
—— *See also* Cardium.
Psammobia rudis, *Lam.*, Bivalve, 48
Headon beds.
Pseudomelania, *see* Chemnitzia.
Pseudomonotis speluncaria, *Schloth.*, Bivalve, 39
Magnesian limestone.
—— *See also* Avicula.
Pterichthys Milleri, *Ag.*, Fish, 37
Lower old red sandstone.
Pterinea spinosa, *Phil.*, Bivalve, 37
Devonian.
Ptychodus latissimus, *Ag.*, Fish (tooth), 45
Chalk.
Ptychopteria damnoniensis, *Sow.*, Bivalve, 37
Upper Devonian.
Pterygotus anglicus, *Ag.*, Eurypterid Crustacean, 37
Lower old red sandstone.
Pupa, *see* Jaminia.
Purpura lapillus, *Linn.*, Gasteropod, 50
Red and Norwich crags—Living (British Seas).
—— tetragona, *J. Sow.*, 49
Red crag.
Purpuroidea Morrisea, *Buv.*, Gast., 41
Great oolite.
Pygaster semisulcatus, *Phil.*, Echinoid, 40
Inferior and Great oolite.
Pyrula nexilis, *Lam.*, Gasteropod, 47
Bracklesham and Barton beds.
—— reticulata, *Lam.*, 49
Coralline and Red crags—Living (Southern Seas).

RHYNCHONELLA ACUMINATA, *Mart.*, Brach., 38
Devonian and Lower carboniferous.
—— concinna, *Sow.*, 41
Inferior and Great oolite series.
—— (Wilsonia) cuboides, *Sow.*, 37
Upper Devonian.
—— cynocephala, *Rich.*, 40
Midford sands.
—— Gibbsiana, *Sow*, 44
Lower greensand.
—— inconstans, *Sow.*, 43
Kimeridge clay.
—— obsoleta *Sow.*, 41
Inferior oolite and Great oolite series.
—— octoplicata, *Sow.*, 45
Upper chalk.
—— Salteri, *Dav.*, 36
Bala beds.
Rhynchonella (Acanthothyris) spinosa, *Schloth.*, 40
Inferior oolite and Fuller's earth.
—— subtetrahedra, *Dav.*, 40
Inferior oolite.
—— tetrahedra, *Sow.*, 40
Middle lias.
—— varians var. socialis, *Phil.*, 42
Oxford clay and Kellaways beds.
Rimella rimosa, *Brand.*, Gasteropod, 47
Bracklesham, Barton and Headon beds.
Ringicula ventricosa, *J. Sow.*, Gast., 49
Coralline, Red and Norwich crags—Living (Southern Seas).

SALENIA PETALIFERA, *Desm*, Echinoid, 44
Upper greensand and Lower chalk.
Sanguinolaria Hollowaysi, *Sow.*, Bivalve, 49
Bracklesham beds.
Saurichthys acuminatus, *Ag.*, Fish, 39
Rhætic beds.
Saxicava rugosa, *Linn.*, Bivalve, 50
Coralline, Red and Norwich crags—Living (British Seas).
Scalaria clathratula, *Adams*, Gast., 49
Coralline crag—Living (British Seas).
—— foliacea, *J. Sow.*, 49
Coralline and Red crags.
—— Grœnlandica, *Chemn.*, 50
Red and Norwich crags—Living (British Seas).
Scalpellum maximum *Sow.*, Cirripede, 45
Middle and Upper chalk.
Scaphites æqualis, *Sow.*, Cephalopod, 45
Lower chalk (Chloritic marl).
Schizodus obscurus, *Sow.*, Bivalve, 39
Magnesian limestone.
—— Schlothheimi, *Geinitz.*, 39
Magnesian limestone.
Scrobicularia plana, *Da C.*, Bivalve, 50
Red and Norwich crags—Living (British estuaries).
Serpula Bognoriensis, *Mant.*, Annelide, 46
London clay
Serpula concava, *Sow.*, Annelide, 44
Gault and Upper greensand.
Sigillaria oculata, *Lindl.*, Lycopod, 38
Coal measures.
—— reniformis, *Brong.*, 38
Coal measures.
Siphonia Königi, *Mant.*, Sponge, 45
Middle and Upper chalk.
—— tulipa, *Zitt.*, 44
Gault and Upper greensand.
Solarium conoideum, *Sow.*, Gasteropod, 44
Gault.
—— ornatum, *Sow.*, 44
Gault and Upper greensand.
Solen obliquus, *Sow.*, Bivalve, 47
Bracklesham beds.
Sphærexochus mirus, *Beyr.*, Trilobite, 36
Bala to Wenlock beds.
Sphærium corneum, *Linn.*, Bivalve, 50
Norwich crag and Cromer Forest bed—Living (Britain).
Sphenopteris linearis, *Sternb.*, Fern, 38
Coal measures.
Spirifer alatus, *Schloth.*, Brachiopod, 39
Magnesian limestone.
—— cuspidatus, *Mart.*, 38
Carboniferous limestone.

Spirifer glaber, *Mart.*, 38
Carboniferous limestone.
—— speciosus, *Schloth.*, 37
Lower and Middle Devonian.
—— striatus, *Mart.*, 38
Carboniferous limestone.
—— undulatus, *Sow.*, 39
Magnesian limestone.
—— Urei, *Flem.*, 37
Upper Devonian and Lower carboniferous.
—— Verneuili, *Murch.*, Brachiopod, 37
Upper Devonian.
Spiriferina Walcotti, *Sow.*, 39
Lower and Middle lias.
Spondylus spinosus, *Sow.*, Bivalve, 45
Middle and Upper chalk.
Stenothyra pupa, *Nyst.*, Gasteropod, 48
Hamstead beds.
—— *See also* Nematura.
Stigmaria ficoides, *Brong.* (Sigillaria), Lycopod, 38
Culm measures and Coal measures.
Stomechinus germinans, *Phil.*, Echinoid, 40
Inferior and Great oolite.
Stringocephalus Burtini, *Defr.*, Brachiopod, 37
Middle Devonian.
Strophalosia lamellosa, *Geinitz*, Brachiopod, 39
Magnesian limestone.
Strophomena depressa, *Dalm.*, Brachiopod, 35
Bala and Llandovery beds.
—— euglypha, *His.*, 36
Llandovery to Ludlow beds.
Syringopora ramulosa, *Goldf.*, Coral, 38
Carboniferous limestone.

TELLINA CALCAREA, *Chemn.*, Bivalve, 50
Red and Norwich crags—Living (British Seas).
—— obliqua, *J. Sow.*, 49
Coralline, Red and Norwich crags, and Cromer Forest bed.
—— prætenuis, *Leathes*, 49
Red and Norwich crags.
Tentaculites annulatus, *Schloth.*, Annelide, 35
Bala beds.
Terebratella pectita, *Sow.*, Brachiopod, 44
Upper greensand and Lower chalk.
Terebratula carnea, *Sow.*, Brachiopod, 45
Middle and Upper chalk.
—— coarctata, *Park.*, 41
Great oolite, Bradford clay and Forest marble.
—— fimbria, *Sow.*, 40
Inferior oolite.
—— flabellum, *Defr.*, 41
Forest marble and Bradford clay.
—— globata, *Sow.*, 40
Inferior oolite and Fuller's earth.
—— grandis, *Blum.*, 49
Coralline and Red crags.
—— (Dielasma) hastata, *Sow.*, 38
Carboniferous limestone.
—— maxillata, *Sow.*, 41
Great oolite series.
—— perovalis, *Sow.*, 40
Inferior oolite.
Terebratula sella, *Sow.*, 44
Lower greensand.
—— (Dielasma) sufflata, *Schloth.*, 39
Permian.
Terebratulina striatula, *Sow.*, Brachiopod, 46
London clay.
Teredina personata, *Lam.*, Bivalve, 46
Woolwich beds and London clay.
Thamnastræa arachnoides, *Park.*, Coral, 42
Corallian.
Theca, *see* Hyolithes.
Thecosmilia annularis, *Flem.*, Coral, 42
Corallian.
Thetis Sowerbyi, *Roem.*, Bivalve, 44
Lower greensand.
Thracia oblata, *Sow.*, Bivalve, 46
Thanet beds and London clay.
Tomichia Duchasteli, *Nyst.*, Gasteropod, 48
Headon, Bembridge and Hamstead Beds.
Trichotropis borealis, *Brod. and Sow.*, Gasteropod, 50
Coralline crag—Living (British Seas).
Trigonia caudata, *Ag.*, Bivalve, 44
Lower greensand.
—— clavellata, *Sow.*, 42
Corallian beds.
—— Trigonia costata, *Sow.*, 40
Inferior oolite to Corallian.
—— dædalea, *Park.*, 44
Upper greensand.
—— gibbosa, *Sow.*, 43
Portland beds.
—— impressa, *Sow.*, 41
Inferior and Great oolite series.
—— incurva, *Benett.*, 43
Portland beds.
—— striata, *Sow.*, 40
Inferior oolite.
Trinucleus concentricus, *Eaton*, Tril., 35
Llandeilo to Llandovery beds.
Trochoceras cornu-arietis, *Sow.*, Ceph., 36
Llandovery and Wenlock beds.
—— giganteum, *Sow.*, 36
Wenlock and Ludlow beds.
Trochotoma obtusa, *Mor. and Lyc.*, Gast., 41
Great oolite.
Trochus cinerarius, *Linn.*, Gasteropod, 50
Red crag—Living (British Seas).
Trophon alveolatus, *J. Sow.*, 49
Coralline and Red crags.
—— (Neptunea) antiquus, *Linn.*, 50
Red and Norwich crags—Living (British Seas).
—— antiquus, *Linn.*, var contraria, 49
Red and Norwich crags—Living (British Seas).
—— Bamffius, *Mont.*, 50
Pleistocene—Living (British Seas).
—— gracilis, *Da C.*, 49.
Coralline and Red crags—Living—(British Seas).
Turbinolia Dixoni, *M. Edw.*, Coral, 47
Bracklesham beds.
Turrilites costatus, *Lam.*, Ceph., 45
Lower chalk.
Turritella granulata, *Sow.*, Gast., 44
Gault and Upper greensand.
—— imbricataria, *Lam.*, 47
London clay, Bracklesham and Barton beds.

Turritella incrassata, *J. Sow.*, 49
Coralline, Red and Norwich crags—Living (Southern Seas).
—— terebra, *Linn.*, Gasteropod, 50
Norwich crag—Living (British Seas).
Typhis pungens, *Brand.*, Gasteropod, 47
Barton and Headon beds.

UNIO COMPRESSUS, *Sow.*, Bivalve, 43
Purbeck and Wealden beds.
—— Gibbsi, *Forbes*, 48
Headon and Hamstead beds.
—— littoralis, *Lam.*, 50
Pleistocene.
—— pictorum, *Linn.*, 50
Norwich (Weybourn) crag and Cromer Forest bed, Pleistocene—Living (Britain).
—— Solandri, *Sow.*, 48
Headon beds.
—— subparallela, *Wood*, 46
Woolwich beds.
—— Valdensis, *Mant.*, 43
Purbeck and Wealden beds.

VALVATA PISCINALIS, *Müll.*, Gasteropod, 50
Norwich crag and Cromer Forest bed—Living (Britain).
Venus casina, *Linn.*, Bivalve, 49
Coralline and Red crags—Living (British Seas)
Vermicularia *see also* Serpula.
Vertigo angustior, *Jeffr.*, Gasteropod, 50
Pleistocene—Living (Britain).
—— pusilla, *Müll.*, 50
Pleistocene—Living (Britain).

Vitrea cellaria, *Müll.*, Gasteropod, 50
Pleistocene—Living (Britain).
Vivipara, *see* Paludina.
Voluta athleta, *Brand.*, Gasteropod, 47
Barton clay.
—— cithara, *Lam.*, 47
Bracklesham beds.
—— Lamberti, *J. Sow.*, 49
Coralline, Red and Norwich crags.
—— luctatrix, *Brand.*, 47
Barton clay.
—— nodosa, *Sow.*, 46
Bracklesham and Barton beds.
—— Rathieri, *Héb.*, 48
Hamstead beds.
—— selseiensis, *Edw.*, 47
Bracklesham beds.
—— spinosa, *Linn.*, 47
Bracklesham, Barton and Headon beds.
—— Wetherellii, *Sow.*, 46
London clay.

WALDHEIMIA DIGONA, *Sow.*, Brachiopod, 41
Great oolite, Forest marble and Cornbrash.
—— lagenalis, *Schloth.*, 41
Cornbrash.
—— numismalis, *Lam.*, 39
Lower and Middle lias.
—— obovata, *Sow.*, 41
Forest marble to Kellaways beds.
—— ornithocephala, *Sow.*, 41
Fullers' earth to Kellaways beds.

XANTHOPSIS LEACHII, *Desm.*, Brachyuran Crustacean, 46
London clay.
Xenophora agglutinans, *Lam.*, Gast., 47
Bracklesham beds and Barton clay.

INDEX.

[All localities are not indexed, as they will be found under their respective counties, or in the descriptions of the main lines of railway.]

ABERDEENSHIRE, 88
Achill Island, 158
Acid rocks, 14, 15, 139
Agates, 82
Agglestone rock, 49
Agriculture, 9-11, 32, 138
Ailsa Craig, 90
Alabaster, 37
Albertite, 38
Alluvium, 34
Alum, 35, 79
Amber, 35
Amethyst, 35
Ammonite zones, 23
Ampthill clay, 25, 43
Anascaul, 140
Andesites, 15, 138
Anglesey, 81
Annandale, 92, 116
Anthracite, 36, 143
Anticlines, 4, 6
Antimony, 35
Antrim, 147
Aran Island, 150
Archæan, 14, 15, 139
Ards, 151
Arenig range, 87
—— rocks, 17
Argyllshire, 89
Arklow, 165
Armagh, 148
Armorican disturbance, 6
Arran, 15, 90, 91
Arran Islands, 153
Arsenic, 35
Artesian wells, 11, 12
Arthur's Seat, 93
Asbestos, 35
Ashby-de-la-Zouch, 59
Assynt, 100
Atherfield Clay, 57
Athole Forest, 97
Avebury, 34, 76
Avon, Bristol, 7
Axholme, 59
Axmouth, 48
Aymestry limestone, 17, 55
Ayrshire, 89

BAGGY BEDS, 18
Bagshot beds, 30
Bala beds, 17, 140
Ballachulish, 89
Ballantrae group, 17
Ballyshannon, 171
Balmoral, 88
Banffshire, 90
Bannisdale slates, 17
Bardsey Island, 83
Bargate stone, 72
Barnesmore, 139, 150
Barnt Green Series, 16, 77
Barr limestone, 70
Barytes, 35
Basalt, 15, 138
Basic rocks, 14, 15, 139
Bass Rock, 94
Bath bricks, 39, 122
—— stone, 38, 121
—— waters, 69
Battock, Mt., 95
Bauxite, 35
Bay-salt, 38
Bear Haven, 149
Beauparc, 159
Bedfordshire, 40
Belfast, 147, 170, 171
Belleek, 152
Bembridge beds, 31
Ben Macdhui, 88
—— Nevis, 94
—— Wyvis, 98
Berkshire, 41
Berwickshire, 90
Berwyn Mountains, 84, 87
Birkhill beds, 17
Bismuth, 35
Black-band ironstone, 37
Black Country, 20, 70
Blackdown Hills, 28, 47, 122
Blackheath Beds, 29
Black Isle, 19, 98
Black-lead, 37, 45
Black Mountains, 54, 83
Blarney, 166
Blea Wyke beds, 79
Blende, 40
Blown Sands, 34, 45, 83, 86, 93, 94, 101, 151
Bog Head Cannel, 38
Bog iron-ore, 37, 159
Bognor rocks, 78
Bog of Allen, 146, 154, 155
Bog slides, 146, 167
Bole, 147
Books on Scenery and Geology, 101, 164
Borings, Deep, 9, 55, 61, 72, 73
Borrowdale Series, 15, 17, 45
Boulder-clay, 32, 103, 145
Bourne, 29
Bovey beds, 48
—— coal, 37
Boyle, 160
Boyne, Vale of, 159
Bracklesham beds, 30
Bradford clay, 24, 75
Braydon Forest, 75
Bray Head, 140, 152
Braythay flags, 58
Brecknockshire, 82
Bredon Hill, 53, 77
Breidden Hills, 87
Brendon Hills, 68
Brent Knoll, 69, 122
Brent Tor, 47
Brickearth, 41, 120
Bridgwater, 39
Bridlington "crag," 80
Brine springs, 39, 43, 59, 77
Broads, 106
Brockram, 21, 75
Brora coal, 100
Brown iron-ore, 37
Buckinghamshire, 41
Budleigh Salterton, 47
Builth wells, 82
Bundoran, 151, 171
Bunter, 21, 22, 143
Burdiehouse limestone, 93
Burntisland, 94
Burren, 142
Burtle beds, 69
Buteshire, 90
Buxton waters, 46

CADER IDRIS, 87
Caer Caradoc, 66
Cænozoic, 13
Caher, 161, 167
Cairngorm Mountain, 90
Cairngorms, 35, 90
Caithness, 91
Calamine, 40
Caldecote volcanic series, 16, 74
Caldy Island, 88
Caledonian Canal, 94
—— disturbance, 6
—— Railway, 116
Calp, 141, 142
Cambrian, 14, 16, 140
Cambridgeshire, 42
Campsie Fells, 99
Cam valley, 52, 104
Canna, 95
Cannel coal, 36, 58, 84
Cannock Chase, 21, 70
Cannon-shot gravel, 103
Cape Clear, 149
Caradoc, 66
—— sandstone, 17
Carboniferous, 14
—— limestone, 19, 141

Carboniferous sandstone, 142
Cardiganshire, 82
Carlingford, 157
Carlow, 148
—— flags, 155
Carmarthenshire, 82
Carnarvonshire, 83
Carnelians, 35, 80
Carrantuohill, 153
Carrick Hills, 17, 89
Carse of Gowrie, 98
Carstone, 106
Cashel, Rock of, 161
Cassiterite, 40
Castlecomer, 155
Cavan, 148
Caves, 46, 48, 55, 84, 85, 147
Celestine, 40, 52
Cement, 37
Cement-stones, 39
Cerussite, 37
Chalcedony, 28, 35
Chalk, 28, 144
Chalk rock, 42
Charnian disturbance, 6
Charnwood Forest, 58, 59
Chatwall sandstones, 67
Cheddar Cliffs, 68
Cheltenham waters, 53
Chert, 35, 47, 85, 142
Cheshire, 43
Chesil beach, 51
Cheviot Hills, 64, 99
Chiltern Hills, 29, 42, 55
China clay, 35, 44
Chines, 54
Chipping Norton limestone, 65
Chiselhurst cave, 132
Chloritic marl, 29, 49, 69
Christian Malford, 121
Clackmannanshire, 91
Clare, 149
—— Island, 158
Claxby iron-ore, 60
Clay, 35
Clay-lumps, 103
Clay-with-flints, 55
Clee Hills, 67
Cleveland Hills, 22, 37, 79
Clew Bay, 157, 158
Clifden, 153, 169
Clifton waters, 53
Clonmel, 161, 167
Clun Forest, 67, 87
Clyde Valley beds, 91, 98
Clyne Hill, 100
Coal, 36
Coal-fields, Bristol, 52; Cheshire, 43; Cumberland, 45; Derbyshire, 46, 64; Irish, 136, 143; Lancashire, 58; Leicestershire, 59; Newcastle, 51, 64; North Wales, 84; Scottish, 90-94, 96, 98; Shropshire, 67; Somerset, 68; South Wales, 61, 83, 85, 87; Staffordshire, 70; Warwickshire, 74; Whitehaven, 45; Wyre Forest, 77; Yorkshire, 46, 64, 78
Coal-measures, 20, 143
Coll, 89
Collyweston slate, 40, 63
Colonsay, 89
Comeragh Mountains, 162
Comley sandstone, 66
Cong, 158
Coniston limestone, 17, 58, 75
—— grits and flags, 17, 58
Connaught, 153, 155, 157, 159, 160
Connemara, 153
Consequent streams, 7
Coombe rock, 73, 74, 130
Coomhola grit, 141
Copper, 36
Coprolites, 38, 42, 71
Coquet Island, 108
Corallian, 25
Coralline Crag, 31, 71
Cork, 149, 166
Cornbrash, 24
Corndon Hill, 87
Cornstones, 19, 61
Cornwall, 43
Cotham marble, 38, 53
Cotteswold Hills, 53
Cowal, 89
Crag, 31, 52, 62, 71
Creech Barrow, 49
Cretaceous, 13, 144
Criffell, 96
Croaghmarhin, 140
Croagh Patrick, 158
Croft Spa, 108
Cromarty, 98
Cromer Forest-bed, 31, 71
Cross-courses, 44
Croydon, 29
Crush-conglomerate, 80
Crystalline rocks, 14
Cuilcagh, 137, 152
Cuillin Hills, 95
Culbin sands, 93
Culm, 36
Culm-measures, 47
Cultivation, Areas under, 10, 138
Cultra, 151
Cumberland, 45
Cumbraes, 90
Curlew Mountains, 160
Curragh, 166

DALES, 46
Dalkey Island, 164
Dalradian, 14
Dartmouth slates, 18
Delphi, 158
Denbighshire, 84
—— grits, 17, 84
Dene-holes, 34, 102
Derbyshire, 46
Derry, 156
Devonian, 14, 18
Devonshire, 46
Dew-ponds, 29
Dhu stone, 38
Diatomaceous earth, 87
Diatomite, 36, 95
Dimetian, 87
Dinas fire-bricks, 20, 39
Dingle beds, 140, 153
Dingle (Dublin), 152
Dirt Bed, 26
Disturbance, Lines of, 6
Doggers, 25, 80
Dogger Series, 79
Dolomite, 36, 59
Donegal, 150
Doolough beds, 140, 158
Doonass, 156
Dorset, 48
Dover coal, 9, 57
—— Straits of, 1
Down, 151
Downton sandstone, 17, 77
Drift, 9, 32, 145
Droitwich, 77
Drumlins, 145
Dry gaps, 146, 152
Dublin, 152, 166, 168, 169
——, Wicklow and Wexford Railway, 164
Dumbartonshire, 92
Dumfries-shire, 92
Dundalk, 157, 169, 170
Dunes, 34
Dungannon, 161
Dungarvan, 162
Dungeness, 57
Dura Den, 93
Durham, 51
Durness limestone, 16, 100
Dykes, 15, 64

EARTHQUAKES, 2
Easdale, 89
East Lothian, 94
Eddystone Lighthouse, 44
Edge Hill, 22, 65, 74
Edinburghshire, 92
Eigg, 15, 95
Elginshire, 93
Elvan, 44
Ely, 105
England, Counties of, 40
Ennis, 149, 168
Enniscorthy, 162, 165
Enniskillen, 152, 170, 171
Entomis, 18
Eocene, 13, 145; Lower, 29; Upper, 30
Eolithic implements, 57, 76, 133
Eriboll quartzite, 100
Erosion, 1, 7, 8
Errigal Mountain, 150
Escarpments, 4, 8
Eskdale granite, 45
Eskers (Kames), 89, 146
Essex, 51
Estuarine beds, 24, 79, 146
Etruria marls, 70
Ettrick Pen, 99
Exmoor Forest, 68

FALMOUTH, 18
Farewell Rock, 20
Farne Islands, 64, 109
Features, Physical, 1
Fells, 45, 78
Felsite, 14, 139, 162, 163
Fenland, 43, 60, 105, 106
Fermanagh, 152
Ferriter's Cove, 140, 154
Festiniog, 86
Fetlar, 97
Fifeshire, 93
Filey Brigg, 80
Fintona, 161
Fire-clay, 35, 78, 84
Fire-stone, 36
Fishguard, 88, 135
Flags, 39, 155
Flamborough Head, 80, 128
Fleet, 50
Flint, 36
Flint implements, 33, 34, 61, 72, 105, 148
Flintshire, 84
Flitwick Spa, 41
Fluor Spar, 36, 46
Folkestone, 57
—— beds, 57, 72
Forest-bed, 31, 71
Forest Marble, 24
Forest of Dean, 52, 53
Forfarshire, 94
Formations, 2, 3; Tables of, 13, 138, 139
Fossils, 1 (Table), 4; List of Figured, 173
Foundry loam, 39
Freestone, 23, 36, 37
Fuller's earth, 23, 27, 36, 67, 72
Fuller's earth formation, 23
Fullonian, 23
Fundamental Gneiss, 14
Furness, 58

GABBRO, 95, 148, 157
Gala beds, 17
Galena, 37
Galley Hill, 134
Galloway, 96
Galtee Mountains, 161
Galway, 153, 169
Gannister, 20, 85
Gap of Dunloe, 153
Garlton Hills, 94
Garnets, 36
Gas, Natural, 73
Gault, 28
Geological Maps, 9
Giant's Causeway, 147
Gigha, 89
Gilsland Spa, 45
Glacial Drift, 9, 32, 145
Glamorganshire, 85
Glasgow and South Western Railway, 112
Glass sands, 27, 39, 42, 57, 72
Glastonbury Tor, 69, 122
Glauconite, 144
Glendalough, Wicklow, 163
Glengariff grits, 141, 153
Glen Roy, 95
Gloucestershire, 52
Gloucester Spa, 53
Gneiss, 14, 16, 98, 99
Gog Magog Hills, 105
Gold, 36, 83, 100, 117, 163
—— Cliff, 61
Golden Cap, 49
—— Vale, 161, 167
Gorran Haven, 18
Gower, 85
Gowlaun beds, 14
Grain, Isle of, 134
Grampians, 5, 88, 94, 97, 99
Granite, 14, 15, 139
Granophyre, 95, 148, 157
Graphite, 37, 45
Graptolites, 17
Gravel, 32, 145
—— ridges, 89, 146
Great Britain, 1
—— Central Railway, 118
—— Eastern Railway, 103
—— Glen, 6, 94
—— Northern Railway, 106
—— Oolite, 23
—— Southern and Western Railway (Ireland), 166
——Western Railway, 120
Green Hills, 146
Greenore, 157, 170
Greensand, 27, 28, 144
Green Slates and Porphyries, 15, 17, 46
Greenstone, 15, 138
Greywethers, 34, 37, 76
Grimes Graves, 62, 105
Grindstones, 64
Grinstead clay, 131
Grits, 25, 39
Gun-flints, 36, 62, 71
Gwespyr sandstone, 85
Gypsum, 37

HADDINGTONSHIRE, 94
Hæmatite, 37
Haldon Hills, 28
Halkin Mountain, 85
Hambleton Hills, 79
Ham Hill, 69
Hampshire, 53
—— Basin, 6
Hamstead beds, 31
Harlech grits, 16
Harris, 95
Harrogate waters, 78
Hartfell Spa, 92
Hartshill quartzite, 16, 74
Hassock, 27, 57
Hastings beds, 27, 73
Head, 45
Headon beds, 31
Hearthstone, 28, 36
Heavitree, 129
Heavy-spar, 35
Hebridean, 14
Hebrides, 95, 99
Herefordshire, 54
Hertfordshire, 55
Hibernian greensand, 144
Highland Railway, 116
Hind Head, 27, 72
Hoar Edge grits, 67
Hollow ways, 50
Hollybush sandstone, 66, 77
Holocene, 13, 138
Holyhead, 81
Holy Island, Northumberland, 109
—— Isle, Buteshire, 90
Holywell shales, 85
Hone-stones, 40, 59
Hordle, 31, 54
Hornblende-schist, 14
Howth Head, 152
Hoy, 97
Hull, 108
Hunstanton Red Chalk, 62
Hunting districts, 9, 42, 59, 63, 66
Huntingdonshire, 55
Hythe beds, 57, 72

IAR CONNAUGHT, 153
Ice-action, 32, 145
Igneous rocks, 14, 139
Ilfracombe beds, 18
Inchmarnock, 90
Inferior Oolite, 23
Inner Hebrides, 95
Innerleithen waters, 97
Intermediate rocks, 14, 15, 139
Inverness-shire, 94
Iona, 89
Ireland, 135
——, Counties of, 147
Ireland's Eye, 152
Iron-ores, 37; Wealden, 27, 73
Iron-pyrites, 37, 51
Islay, 89
Isle of Axholme, 59
—— Ely, 105
—— Grain, 134
—— Man, 80
—— Sheppey, 56, 57, 133
—— Thanet, 56, 133
—— Wight, 28, 30, 54

JARROW, KILKENNY, 155
Jaspers, 82
Jet, 37, 79
Joyce's Country, 153
Jura, 89
Jurassic, 13

KAMES (Eskers), 89, 146
Kaolin, 35, 44
Keele sandstone, 70
Keisley, 17
Kellaways beds, 24, 121
Kenmare, 153, 167
Kent, 56
Kentish Rag, 27, 57, 72
Kerry, 153

Kesh, 160, 171
Keuper, 21, 22, 143
Kildare, 154, 166
Kilkenny, 155
Killarney, 137, 153, 167
Killary Harbour, 153, 158
Killas, 18, 43
Kilpatrick Hills, 92
Kiltorcan beds, 141, 155
Kimeridge clay, 25
—— coal, 50
Kincardineshire, 95
King's County, 155
Kingstown, 135, 164
Kinross-shire, 96
Kintyre, 89
Kirkby Moor flags, 17
Kirkcudbrightshire, 96
Kitchen-middens, 150
Knockmealdown Mountains, 161, 162

LACCOLITES, 15, 87
Lackagh Hills, 156
Lake District, 45, 58, 75
Lambay Island, 152
Lammermuir Hills, 5, 90, 94
Lanarkshire, 96
Lancashire, 58
Landscape marble, 38, 53
Landslips, 28, 48, 54, 67, 133, 146
Langdon Hill, 102
Larne, 144, 147, 172
Leadhills, 37, 39, 40, 92, 96
Lead-ore, 37
Lead-pencils, 45
Ledbury, 125
Ledbury shales, 77
Leenane, 153
Leeswood, 84
Leicestershire, 58
Leinster, 148, 152, 154, 155, 157-159, 162, 163
Leintwardine, 18
Leith Hill, 27, 72
Leitrim, 155
Lenham, 31
Lesmahagow beds, 17
Lewis, 99
Lewisian, 14, 99
Liassic, 13, 14, 144
Lickey Hills, 77
Lignite, 37, 145
Limavady, 156
Lime, 37
Limerick, 156, 167
Limestone, 37
Limonite, 37
Lincoln Cliff, 60
Lincolnshire, 59
Lingula Flags, 16
Linlithgowshire, 96
Lisbellaw, 152
Lisdoonvarna, 149
Lismore Island, 89
——, Waterford, 162
Llanberis slates, 16
Llandeilo beds, 17, 83, 140
Llandovery beds, 17, 83, 140
Llandrindod Wells, 88
Llangammarch Wells, 82
Llanvirn beds, 17
Llanwrtyd Wells, 82
Lleyn, 83
Lochaber, 95
Loch Eriboll, 100
Lochnagar, 88
Lodes, 44
Lomond Hills, 93, 96, 109
London and North Western Railway, 113
—— and South Western Railway, 127
—— Basin, 6
—— Brighton and South Coast Railway, 130
—— Tilbury and Southend Railway, 102
Londonderry, 156, 172
Longford, 157
Long Island, 95, 99
—— Mountain, 87
Longmynd, 66
Longmyndian, 14
Lough Neagh beds, 145, 148
Loughrea, 153, 168
Louth, 157
Lower Greensand, 27
Lowther Hills, 92, 96
Lucan, 152, 166
Ludlow beds, 17, 140
Lugnaquilla, 163
Lundy Island, 47
Lydian stone, 147
Lyme Regis, 49, 129
Lynchets, 114, 127

MAGEE ISLAND, 147
Magheramorne, 172
Magnesian Limestone, 21, 51
Magnetic iron-ore, 37, 79
Mallow, 150, 166
Malvern, 5, 52, 55, 77
—— shales, 16, 77
Malvernian disturbance, 6
Mam Tor, 46
Man, Early history of, 34
Man, Isle of, 80
Manganese, 38
Mansfield stone, 38, 64
Manure gravels, 145, 163
Manx slates, 16, 80
Maps, Geological, 9
Marble, 38, 39
—— Arch, 137, 152
Marwood beds, 18
Matlock waters, 46
May Hill, 52, 55
—— —— sandstone, 17
Mayo, 157
McGillicuddy's Reeks, 137, 153
Meath, 158
Megaceros-marl, 146
Melbourn rock, 42
Melksham Spa, 75
Mendip Hills, 68, 122
Menheniot, 122
Meres, 43, 68, 105
Merionethshire, 86
Mesozoic, 13
Metamorphic rocks, 13, 15, 139
Metropolitan Railway, 118
Middlesex, 60
Midland Railway, 109
—— Great Western Railway (Ireland), 168
—— Railway, Northern Counties Section (Ireland), 171
Midlothian, 92
Millstone grit, 20, 142
Mineral products, 35
—— veins, 44
—— waters, *see under* Counties
Miocene, 7
Mitchelstown, 149, 1 6
Modelling clay, 36
Moelwyn, 87
Moel-y-Tryfan, 84
Moffat Series, 17
—— Spa, 92
Moher, 142, 149
Moira, 151
Monadhliath Mountains, 94
Monaghan, 159
Mona marble, 81
Monmouthshire, 61
Montgomeryshire, 87
Moorfoot Hills, 17, 92, 97
Moray, 93
Morte Slates, 37, 47
Morven, 89
Moulding sands, 39
Mountains, 4, 136
Mountain Limestone, 19
Mount Battock, 95
Mourne Mountains, 151
Muck, 95
Mulatto stone, 144
Mull, 89
Munster, 149, 153, 156, 160, 162
Mweelrea, 140, 158
Mylor, 18

NAIRNSHIRE, 97
Natural gas, 73
Needwood Forest, 71
Nen, River, 56, 11
Neolithic, 13, 146, 148, 160
Neville Holt Spa, 59
New Forest, 54
New Red sandstone, 13
Newry, 148, 170
Norfolk, 62
Northamptonshire, 63
North British Railway, 109
—— Eastern Railway, 108
Northumberland, 63
Norwich Crag, 31, 62, 71
Nottinghamshire, 64

OBSEQUENT STREAMS, 7
Ochil Hills, 5, 19, 91, 96, 98
Ochre, 38
Oil-shale, 38, 84, 92, 93, 96
Oilstone, 40

Oldhaven beds, 29, 30
Old Red sandstone, 14, 19, 140
Oligocene, 13, 31
Omagh, 161
Oolitic, 13, 23
Oolite, Lower, 23; Middle, 24; Upper, 25
Ophicalcite, 39
Ordovician, 14, 17, 140
Orkney, 97
Orston Spa, 65
Osborne beds, 31
Outer Hebrides, 95, 99
Outliers, 8
Overflow channels, 146
Overthrusts, 16, 100
Overlap, 6
Ovoca, 163, 165
Owenduff beds, 140
Ox Mountains, 139, 160, 168
Oxfordshire, 65

Pabba, 95
Palæolithic implements, 33, 34, 61, 72, 105
Palæozoic, 14; in Eastern England, 8, 9, 55, 57, 72
Paramoudras, 62, 144
Parrot coal 36
Partry Mountains, 158
Paving stone, 39, 59
Peak District, 46
Peat, 34, 38, 146
—— mosses, 43, 58
Pebbles, 82
Pebidian, 14, 16, 87
Peckforton Hills, 43
Peebles-shire, 97
Pembrokeshire, 87
Pendleside group, 19, 142
Penlee stone, 15
Pennant grit, 20
Pennine anticline, 4, 5
—— chain, 78
Penrith sandstone, 21
Pentland Hills, 17, 97
Perched Blocks, 32, 33
Periods, Geological, 2
Permian, 13, 21, 143
Perthshire, 97
Petrifying springs, 46, 53, 78
Petroleum, 38
Phosphates, 38, 42, 71
Pilton beds, 18
Pipe clay, 30, 35, 145
Pipes in chalk, 55, 57
Pitchblende, 40
Pitchstone, 15, 139
Pladda, 90
Plain, Central, Ireland, 135, 136
—— (or plane) of marine denudation, 7, 8
Pleistocene, 13, 32, 145
Pliocene, 13, 31, 145
Plumbago, 37, 45
Plynlimmon, 82
Polden Hills, 22, 68
Pomeroy, 140, 161
Poolvash, 81
Population, Influence of Geology on, 9
Portland beds, 26
—— cement, 29, 37
—— Isle of, 50
Portrush, 147
Portscatho, 18
Pot-holes, 49, 78
Potteries, 20, 70, 78, 153
Potters' clay, 30, 35
Pre-Cambrian, 14, 15
Precelley Hills, 88
Primary, 14
Pudding-stone, 30, 55
Puffin Island, 81
Purbeck, 13, 26
—— Isle of, 48, 49
Purton Spa, 75
Pyrites, 37, 51
Pyrolusite, 38

Quantock Hills, 68
Quartz, 35
Quartzites, 16, 139
Quaternary, 13
Queen Camel, 69
Queen's County, 159

Raasay, 95
Raddle, 38
Radiolarian chert, 35, 47
Radium, 40, 69
Radnor Forest, 88
Radnorshire, 88
Railways, 102, 164
Raised Beaches, 33, 48, 146, 150
Rathdrum, 163, 165
Rathlin Island, 147
Reading beds, 30
Recent, 13, 32, 145
Recess, 153
Red Chalk, 28, 60, 62
—— Crag, 31, 71
—— Hills of Skye, 95
Reddle, 38
Renfrewshire, 98
Residential sites, 12, 13
Rhætic, 21, 22, 143
Rhyolite, 139, 157, 171
Riccarton beds, 17
Rivers, History of, 7
Road-metal, 38, 59
Roches moutonnées, 32, 33
Rock-salt, 43
Roman cement, 39, 52
Romney Marsh, 57
Rootlet bed, 71
Roscommon, 159
Roslyn Hole, 42, 105
Rosslare, 135, 163, 165
Ross-shire, 98
Rostrevor, 151
Roswell Hole, 42, 105
Rottenstone, 38
Rowley Rag, 70
Roxburghshire, 99
Royston Downs, 29, 51, 55
Rum, 95
Rutlandshire, 66

St. Kilda, 95
Salisbury Plain, 76
Salrock beds, 140
Salt, 38
Saltee Islands, 163
Sand-floods, 45, 93, 105
Sandgate beds, 57, 72
Sandringham sands, 28
Sands, 39
Sandstone, 39
Sarsen stones, see Greywethers
Saurians, 50, 69
Scalp, 152
Scalpa, 95
Scarborough, 79, 80
Scenery, Relation of formations to, 1, 4, 6, 9, 102, 135, 164
Schistose rocks, 14, 16, 139
Schorl, 40
Scilly Isles, 44
Scotland, Counties of, 88
Scythe-stones, 129
Sea-side resorts, *see* under Counties
Secondary, 13
Sedgemoor, 69
Sedimentary rocks, 14, 138
Seepage, 11
Selborne, 54
Selbornian, 13, 28
Selenite, 37
Selkirkshire, 99
Septaria, 39
Serpentine, 15, 39, 138, 153
Settle, 78, 111
Shandon, 162
Shanklin Spa, 54
Shap granite, 75
—— wells, 75
Shearsby Spa, 59
Shell-beds, 58
Shelve, 17
Sheppey, 56, 57, 133
Sherwood Forest, 64
Shetland, 97
Shiant Isles, 95
Shineton shales, 66
Shirdley Hill sand, 58
Shivering Mountain, 46
Shropshire, 66
Sidlaw Hills, 19, 94
Silchester, 53
Silica-stone, 20, 39
Silicified wood, 145
Sills, 15
Silurian, 14, 17, 140
Silver, 39
Silvermines, 161
Sites for residences, 12, 13
Skelligs, 153
Skiddaw slates, 16, 17, 45, 75
Skye, 95
Slane, 159

Slate, 39
Slate-pencils, 39, 45, 51
Slate-quarries, 83
Slieve Donard, 151
—— Gallion, 157
—— Gullion, 148, 157
—— League, 150
Sligo, 160, 168
——, Leitrim & Northern Counties Railway, 170
Smerwick, 154
Snowdon, 5, 17, 83
Soap-stone, 39, 40
Soils, 9, 10, 138
Solid formations, 9, 145
Somerset, 68
South Eastern and Chatham Railway, 131
Southern Uplands, 89, 92, 96, 99
South Stack, 81
Spathose iron-ore, 37
Speeton clay, 28
Sperrin Mountains, 157, 161
Spilsby sandstone, 28
Sponge-gravels, 27
Springs, 11, 12
Staffa, 89
Staffordshire, 70
Stanmore, 113
Steam-coals, 36
Steatite, 39, 40
Stibnite, 35
Stilton, 56
Stiper stones, 17, 67
Stirlingshire, 99
Stockdale shales, 17
Stockingford shales, 74
Stonehenge, 34, 76
Stonesfield slate, 40, 65
Stone-tiles, 40
Strathpeffer Spa, 98
Strontium, 40, 52
Subsequent streams, 7
Subsoils, 10
Subterranean erosion, 8
Subwealden Boring, 73
Suffolk, 71
Sugar Loaf, Monmouth, 61
—— Wicklow, 164
Surrey, 72
Sussex, 73
—— marble, 27, 73
Sutherlandshire, 99
Sutors of Cromarty, 99
Sutton stone, 86
Swallet Holes, 49, 78
Swanage, 49
Swindon, 76, 121
Syenite, 45, 58
Synclines, 4

TALC, 40
Tara, Hill of, 159
Tarannon shales, 17
Tardree, 139
Tealby beds, 28
Temperature, Increase of, 2
Templepatrick, 171
Tenby, 88
Terra-cotta clay, 35, 111, 163
Tertiary, 13, 145
Thames, River, 7
—— Valley deposits, 52, 61, 102, 120
Thanet beds, 29
—— Isle of, 56, 133
Thurso, 91
Till, 32
Time, Geological, 3
Tin-ore, 40, 163
Tinto Hills, 96
Tipperary, 160, 167
Tiree, 38, 89
Toadstone, 46
Topaz, 40
Torbane Hill, 38
Torridonian, 14, 98, 100
Tors, 47, 151
Totternhoe stone, 42
Tourmaline, 40
Tralee, 153, 167
Trap rocks, 15
Trefriw, 84
Tremadoc slates, 16
Triassic, 13, 21, 143
Trilobites, 16-18
Trossachs, 97
Tuedian, 90
Tufa, 53
Tunbridge Wells, 57
—— —— —— sand, 27, 73
Tungsten, 40
Tunnel, Scotland to Ireland, 135
Turf bogs, 146
Tuskar rock, 163
Twelve Pins, 153
Tyrone, 161

ULSTER, 147, 148, 150-152, 156, 159, 161
Ultra-basic rocks, 14, 15, 139
Umber, 40
Unst, 97
Upper Greensand, 28
Uranium, 40
Uriconian, 14, 16, 66, 77

VALES, 9
Vale of Aylesbury, 25
—— Blackmore, 25, 50, 128
—— Boyne, 159
—— Clara, 163
—— Clwyd, 84, 85
—— Eden, 21, 45, 112
—— Glamorgan, 86
—— Gloucester, 53
—— Llangollen, 84
—— Neath, 85
—— Ovoca, 163, 165
—— Pickering, 25, 79, 80
—— Taunton, 22, 122
—— Wardour, 26, 76, 128
—— York, 78, 79, 108
Valencia Island, 153
Valley of elevation, 55
Valley deposits, 33, 145
Valleys, Erosion of, 7, 8, 150

WADHURST CLAY, 27
Wales, Counties of, 81
Wallsend, 64
Walthamstow, 104
Wardie, 92
Warp, 60
Warwickshire, 74
Watcombe clay, 47
Waterfalls, 45, 84, 86, 96, 164
Waterford, 162, 165, 167
Water-supply, 11, 12
Weald clay, 27
Wealden, 13, 27
—— area, 6, 8
—— iron-ore, 27, 73
Weaver Hills, 70
Wenlock beds, 17, 140
—— Edge, 67
Westleton beds, 72, 104
Westmeath, 162
West Lothian, 96
Westmorland, 75
Westport, 158, 168
Wexford, 162, 165
Weymouth, 49, 50
Whin Sill, 64, 75
Whitby, 79
White Horse, 121
Whiting, 37, 41, 172
Wicklow, 163, 165
Wight, Isle of, 28, 30, 54
Wigtownshire, 101
Wiltshire, 75
Windsor, 41, 120
Wirral, 43
Witherite, 35
Wittering Spa, 63
Woburn Hills, 27, 41
Wolds of Lincolnshire and Yorkshire, 29, 60, 80
Wolfram, 40
Wolf rock, 44
Woodhall Spa, 60
Woolhope beds, 17
Woolwich and Reading beds, 30
Worcestershire, 77
Wrekin, 66
—— quartzite, 16
Wren's Nest, 70
Wychwood Forest, 65
Wyre Forest, 67, 77

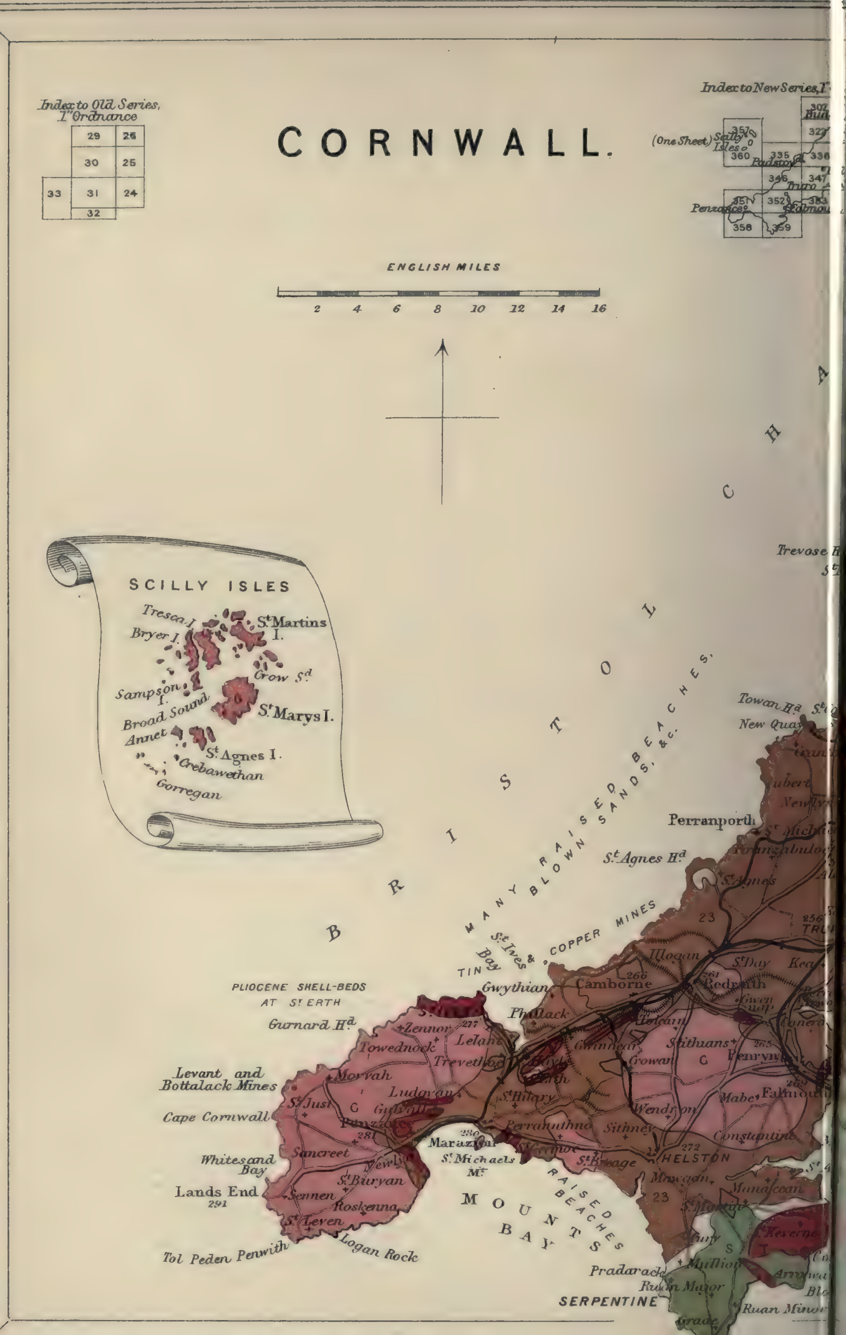
YARROW, 99
Yell, 97
Yellow sandstone, 140
Yeovil sands, 129
Yoredale rocks, 19
Yorkshire, 77

ZINC-ORE, 40
Zones, 3; in Chalk, 29; in Lias, 23

NOTE.

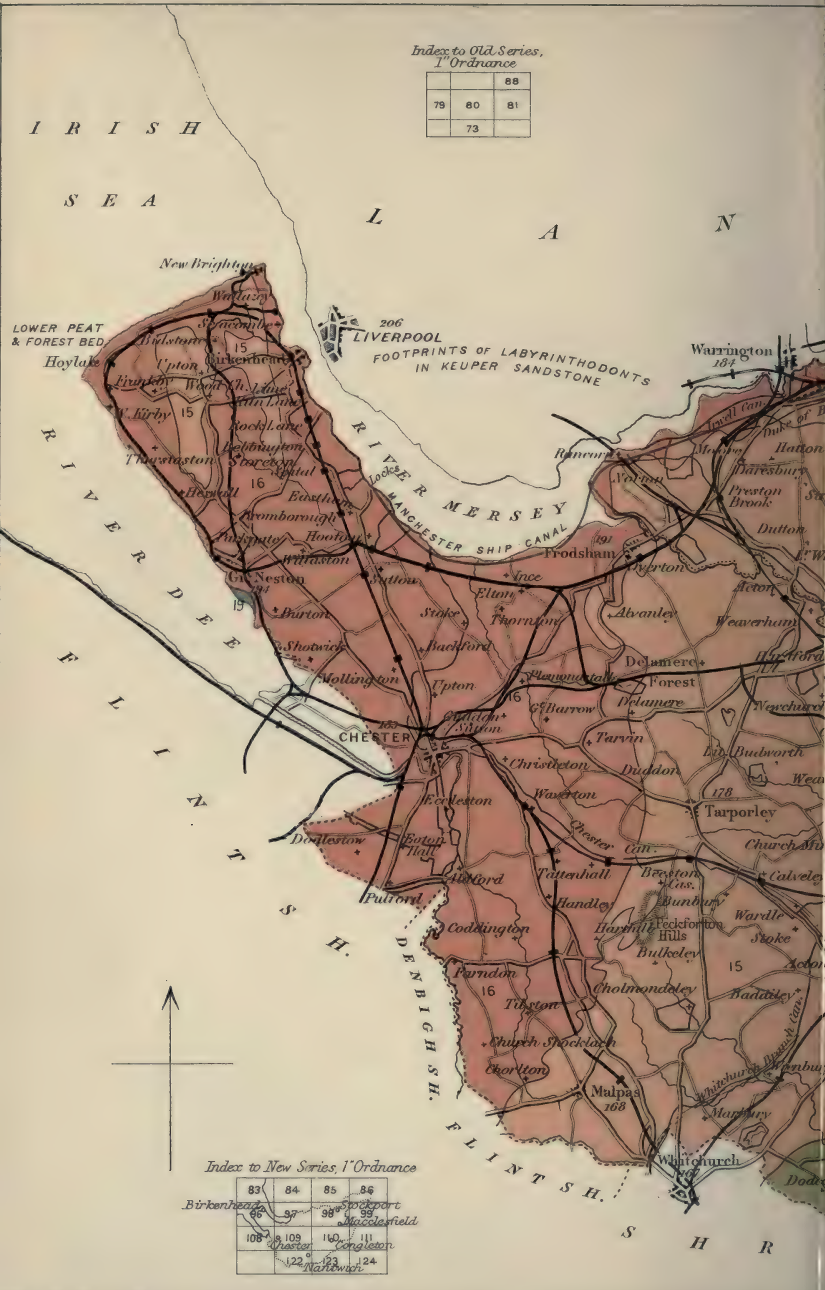
The Index tablets to the Geological Maps will be found in the Folding Table, p. 1.

The smaller numerals on the English county-maps indicate the distances in miles from London.

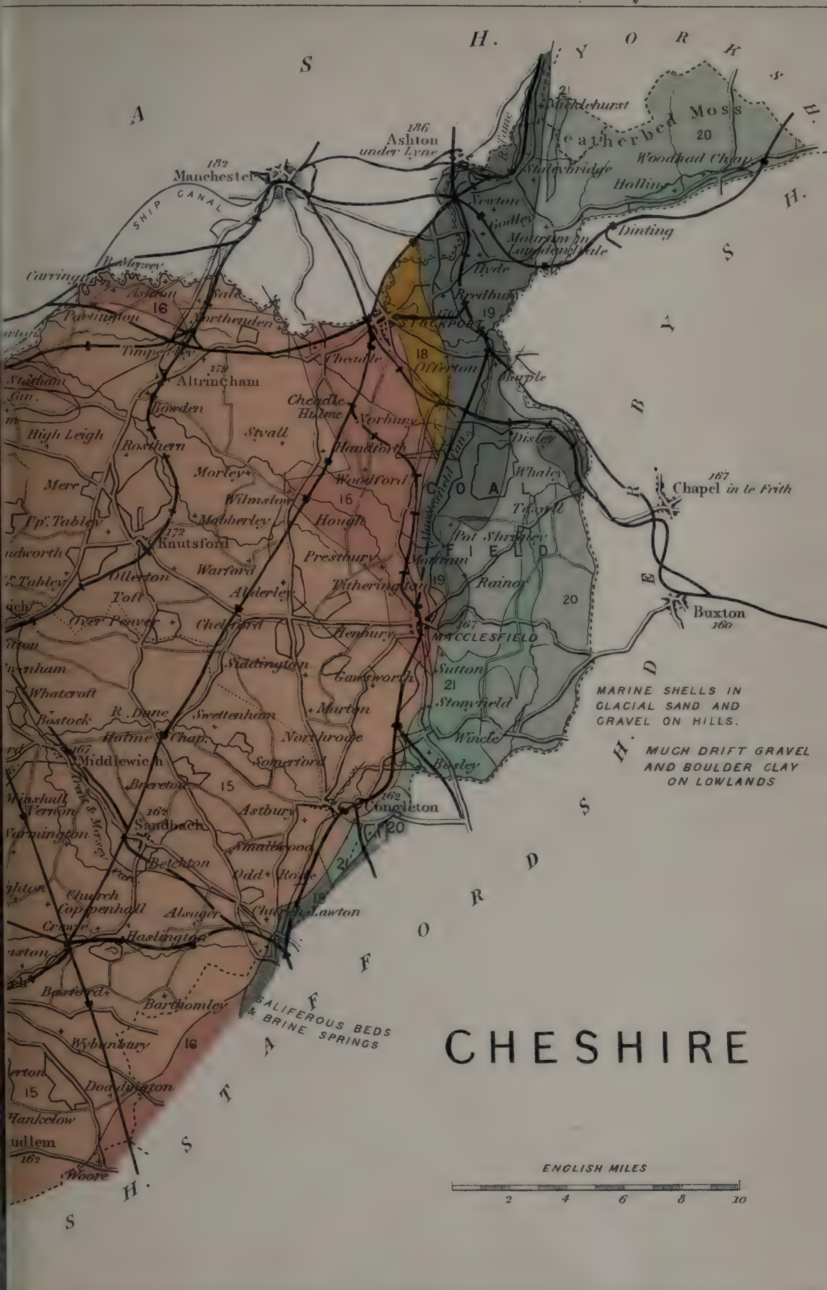


CORNWALL.
Index to Old Series, 1" Ordnance
29
26
30
25
33
31
24
32
Index to New Series, 1"
(One Sheet) Scilly Isles
ENGLISH MILES
2 4 6 8 10 12 14 16
SCILLY ISLES
Tresco I.
Bryer I.
St. Martins I.
Crow Sd.
Sampson I.
Broad Sound
St. Marys I.
Annet
St. Agnes I.
Crebawethan
Gorregan
BRISTOL CHANNEL
Trevose Hd.
Towan Hd.
New Quay
Perranporth
St. Agnes Hd.
St. Agnes
MANY RAISED BEACHES,
BLOWN SANDS, &c.
TIN & COPPER MINES
St. Ives Bay
PLIOCENE SHELL-BEDS AT ST. ERTH
Gurnard Hd.
Zennor
Towednack
Lelant
Gwythian
Phillack
Camborne
Illogan
Redruth
St. Day
Kea
Levant and Bottalack Mines
St. Just
Cape Cornwall
Ludgvan
Gulval
Penzance
Marazion
St. Michaels Mt.
St. Hilary
Perranuthnoe
Gwinnear
Crowan
Stithians
Penryn
Falmouth
Mabe
Wendron
Sithney
Constantine
Whitesand Bay
Sancreet
Newlyn
St. Buryan
Lands End 291
Sennen
Roskenna
St. Leven
Logan Rock
Tol Peden Penwith
St. Breage
HELSTON
Mawgan
Manaccan
St. Keverne
MOUNTS BAY
RAISED BEACHES
Pradarack
Mullion
Ruan Major
Ruan Minor
SERPENTINE
Grade

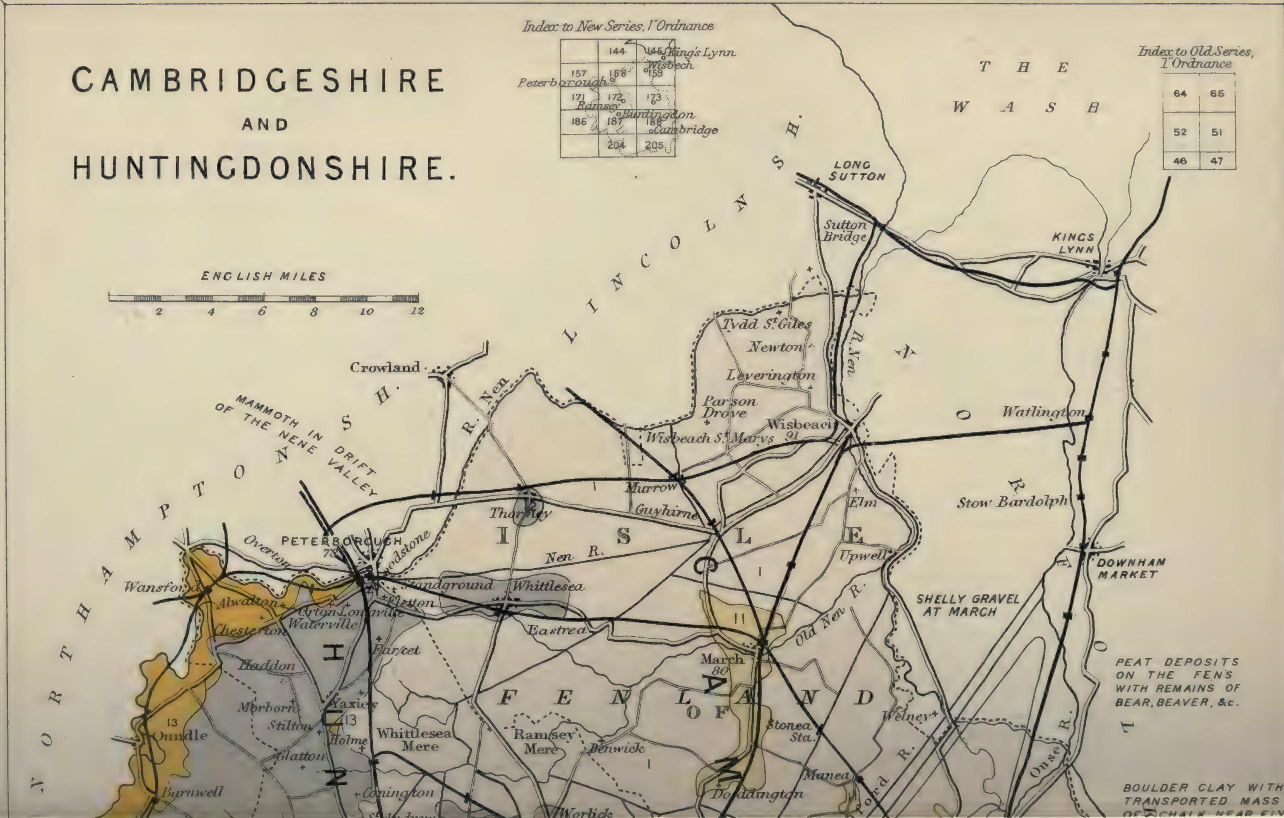

Sharp Nose Pt
Moorwinstow
Kilkhampton
Pegdon
Poughill
Bude
Stratton
Launcells
Marhamchurch
Widemouth
20
CULM MEASURES, NO COAL.
Poundstock
Whitestone
Week St Mary
Tamerton
S. Gennys
Jacobstow
Boyton
Boscastle
St Juliett
Forrabury
Trevulga
Tintagel
Lesnewth
Otterham
Warbstow
Tremayne
Egloskerry
St Stephens
Davidstow
Tresmeer
Trewen
LAUNCESTON
214
Lawhitton
Lidford
Treligga
CAMELFORD
228
Delabole
Laneast
Alternon
Brown Willy
Advent
Port Isaac
Point
Michaelstow
St Breward
St Teath
Endellyon
St Minver
St Michael
Kew
St Tudy
Dinham
Bodmin Moor
Temple
Linkinhorne
Stoke Climsland
Kit Hill
Blisland
Wadebridge
239
St Ervan
Egloshale
Warleggon
St Neot
St Ive
CALLINGTON
Calstock
St Dominic
St Mellion
TAVISTOCK
207
BODMIN
Cardinham
Withiel
23
Quethiock
Pillaton
LISKEARD
224
Menheniot
Botus Fleming
Landrake
SALTASH
220
S. Wenn
St Columb Major
246
Lanivet
Lanhydrock
Braddock
St Pinnock
St Keyne
Boconnock
LOSTWITHIEL
234
Lanlivery
Luxulian
St Winnow
Duloe
Morval
St Germans
Trigonna Hill
St Dennis
Hensbarrow
St Blazey
St Stephens
St Austell
243
Lanreath
St Veep
Pelynt
St Martins
Sheviock
Antony
Tywardreath
W. LOOE
Talland
E. LOOE
234
Millbrook
222
Maker
Oreston
Rame
Plymouth Sd
Breakwater
FOWEY
Trevissick
St Mewan
Grampound
248
Probus
Creed
TREGONY
253
St Ewe
St Michael Carhayes
25
Lamorran
Veryan
Veryan Bay
Gerrans Bay
Gerrans
262
MAWES
BEACHES NUMEROUS
Black Hd
Mevagissey
Gorran Haven
Lanteglos
Lansellos
Polperro
FOSSIL FISHES IN FOWEY BEDS
CHINA CLAY, ST AUSTELL
SUBMERGED FOREST.
ORGANIC REMAINS, -ORTHIS, CALYMENE- IN LOWER SILURIAN OR ORDOVICIAN
ELEPHANT, BEAR, RHINOCEROS, IN ORESTON CAVES.
Eddystone Lt Ho.
GNEISS
ENGLISH CHANNEL
COPPER MINES AT CALLINGTON &c.
LEAD MINES AT LISKEARD.
CALCAREOUS SLATE AND FLAGSTONES. UNPRODUCTIVE COALS
ROCKS WITH FOSSILS OF DEVONIAN.
DEVON
DEVONSH.
R. Tamar
NEL
6



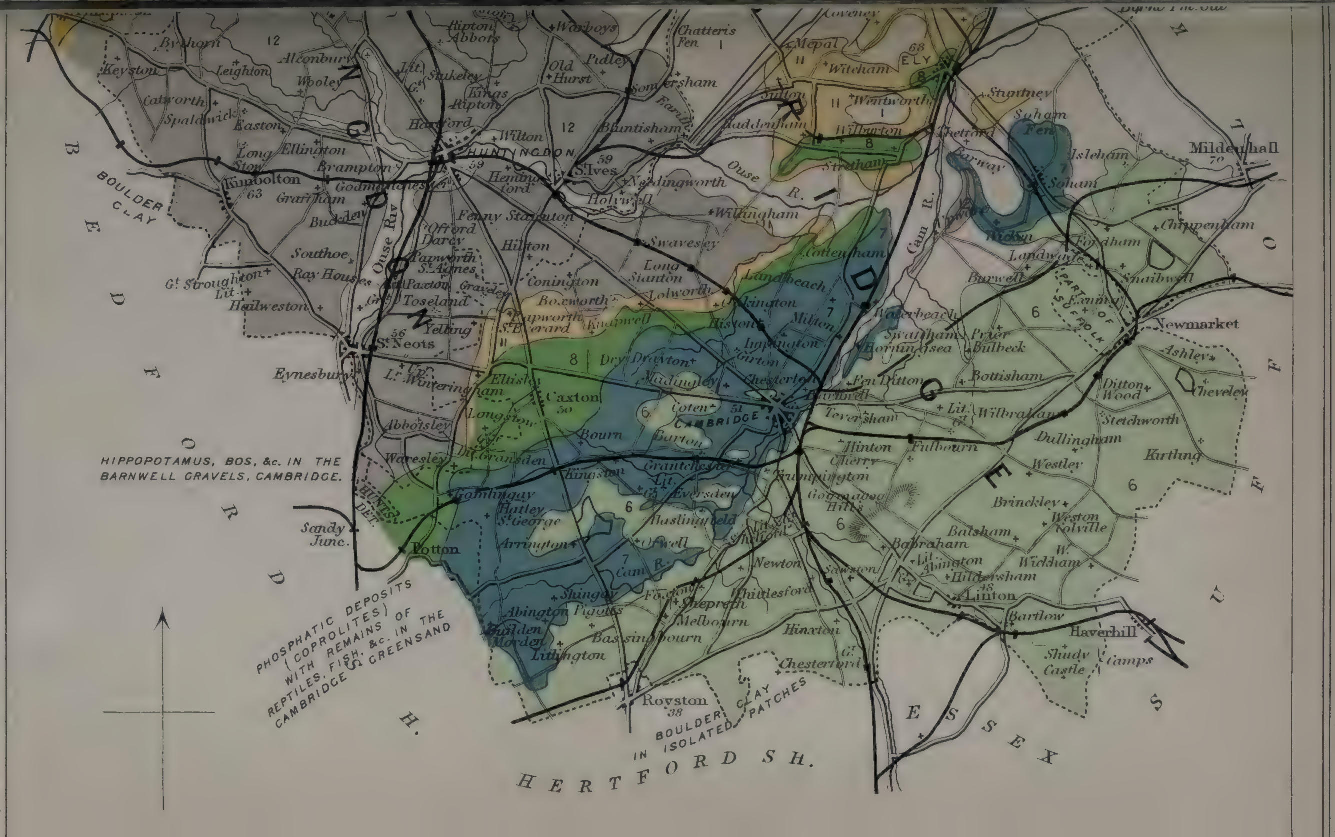
Index to Old Series, 1" Ordnance
88
79
80
81
73
IRISH SEA
LANCASHIRE
LOWER PEAT & FOREST BED
New Brighton
Wallasey
Seacombe
Bidston
Birkenhead
Hoylake
Upton
Frankby
Woodchurch
W. Kirby
Rock Lane
Bebbington
Thurstaston
Storeton
Spital
Heswall
Eastham
Bromborough
Parkgate
Hooton
Willaston
Gt. Neston
Burton
Shotwick
Mollington
Sutton
Stoke
Backford
Upton
CHESTER
Ince
Elton
Thornton
Frodsham
Overton
Alvanley
206
LIVERPOOL
FOOTPRINTS OF LABYRINTHODONTS IN KEUPER SANDSTONE
RIVER MERSEY
MANCHESTER SHIP CANAL
Locks
RIVER DEE
Warrington
184
Runcorn
Norton
Moore
Hatton
Daresbury
Preston Brook
Dutton
Acton
Weaverham
Delamere Forest
Delamere
Gt. Barrow
Tarvin
Christleton
Duddon
Waverton
Eccleston
Tarporley
Chester Can.
Eaton Hall
Dodleston
Pulford
Aldford
Tattenhall
Handley
Beeston Cas.
Bunbury
Peckforton Hills
Harthill
Bulkeley
Coddington
Farndon
Tilston
Cholmondeley
Church Shocklach
Chorlton
Malpas
168
Whitchurch
Marbury
Wrenbury
Wardle
Stoke
Calveley
Church Minshull
Baddiley
Whitchurch Branch Can.
Little Budworth
FLINTSH.
DENBIGH SH.
FLINTSH.
SHR
Index to New Series, 1" Ordnance
83
84
85
86
Birkenhead
96
97
98
99
Stockport
Macclesfield
108
109
110
111
Chester
Congleton
122
123
124
Nantwich



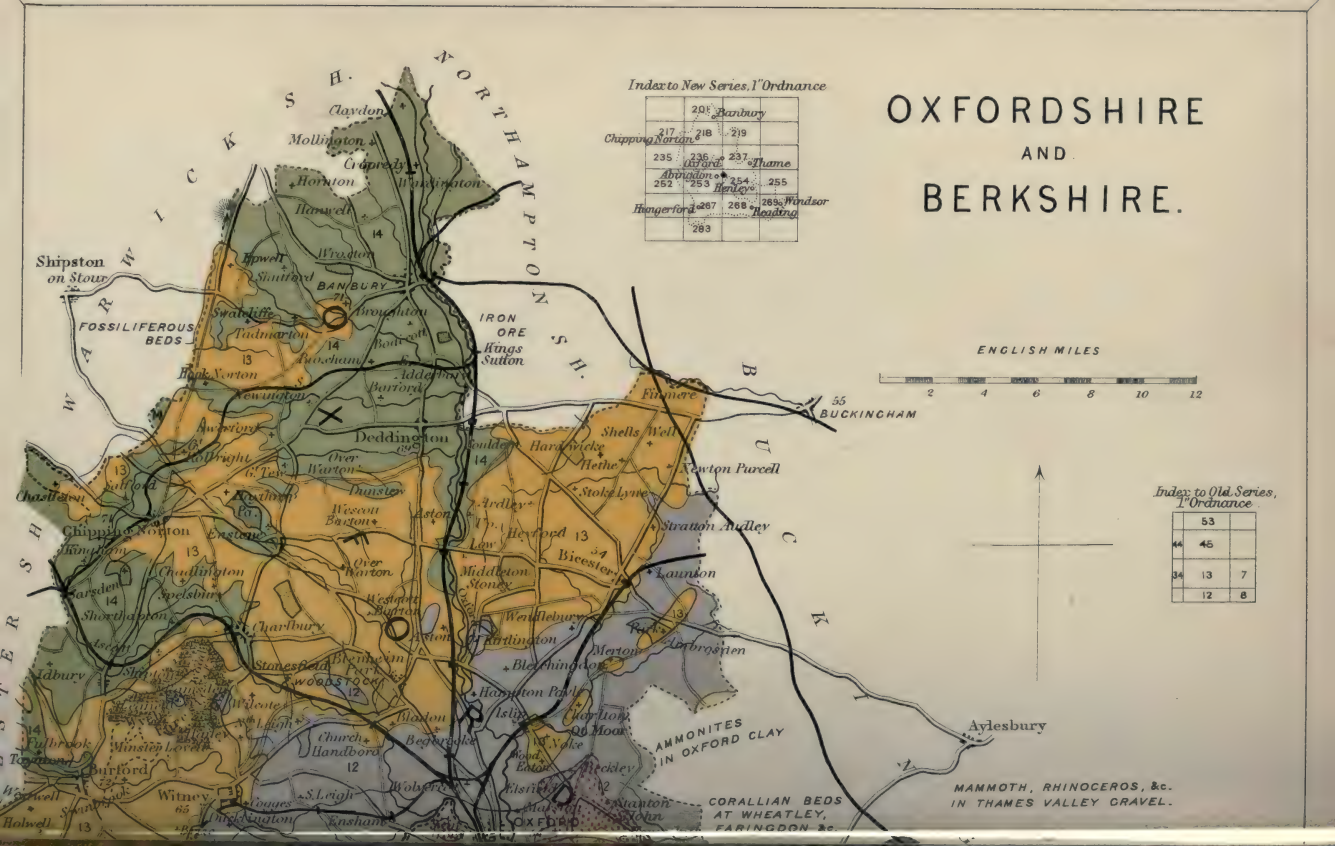
CHESHIRE
MARINE SHELLS IN GLACIAL SAND AND GRAVEL ON HILLS.
MUCH DRIFT GRAVEL AND BOULDER CLAY ON LOWLANDS
SALIFEROUS BEDS & BRINE SPRINGS
COAL FIELD
ENGLISH MILES
2 4 6 8 10
Manchester
Ashton under Lyne
Stockport
Altrincham
Knutsford
Macclesfield
Congleton
Sandbach
Middlewich
Buxton
Chapel in le Frith



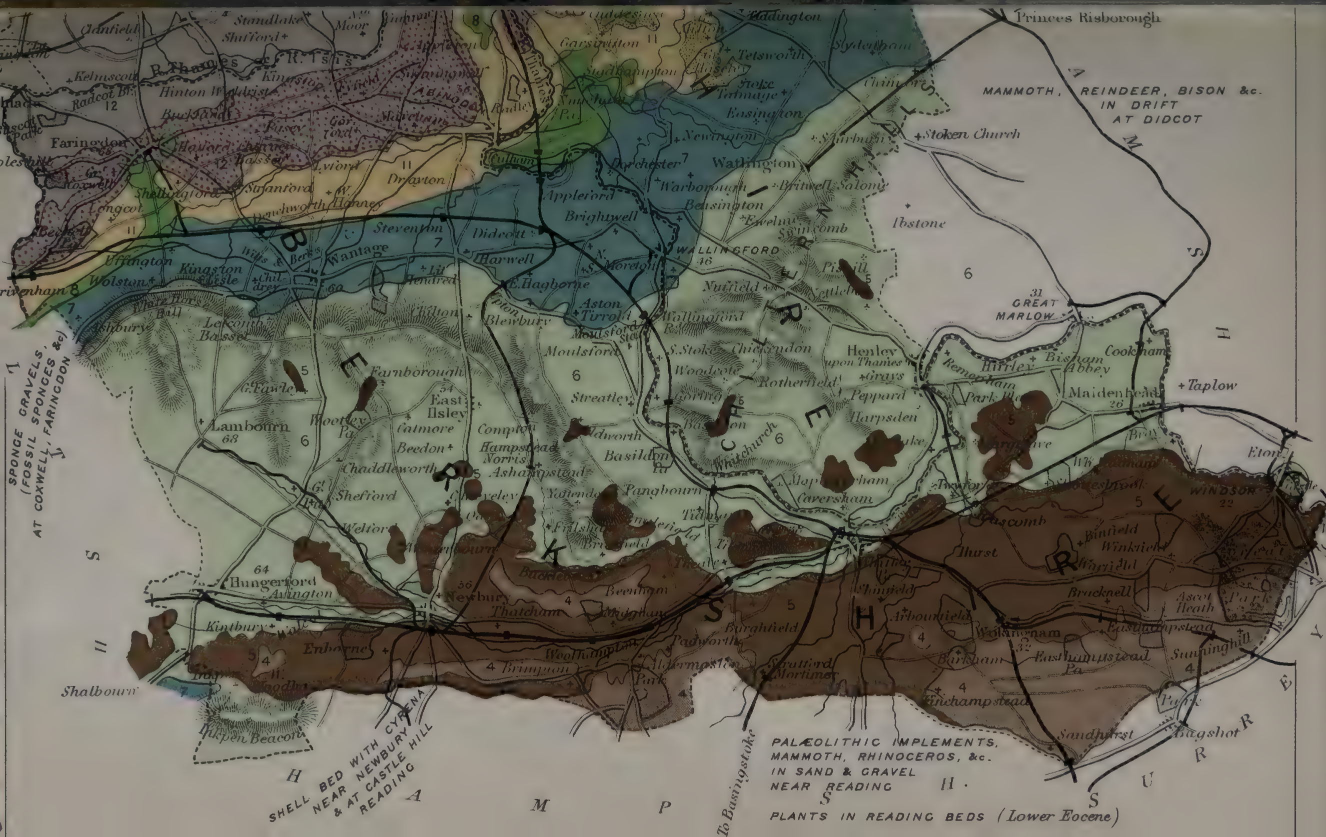
CAMBRIDGESHIRE
AND
HUNTINGDONSHIRE.
Index to New Series, 1" Ordnance
144
145 King's Lynn
Wisbech
157
158
159
Peterborough
171
172
173
Ramsey
Huntingdon
186
187
188
Cambridge
204
205
Index to Old Series, 1" Ordnance
64
65
52
51
46
47
THE WASH
ENGLISH MILES
2 4 6 8 10 12
LINCOLNSH.
NORTHAMPTONSH.
NORFOLK
LONG SUTTON
Sutton Bridge
KINGS LYNN
Tydd St. Giles
Newton
Leverington
Parson Drove
Wisbeach
91
Wisbeach St. Marys
R. Nen
Watlington
Stow Bardolph
DOWNHAM MARKET
Crowland
MAMMOTH IN DRIFT OF THE NENE VALLEY
Murrow
Guyhirne
Thorney
Elm
Upwell
ISLE OF ELY
PETERBOROUGH
78
Overton
Woodstone
Nen R.
Stanground
Whittlesea
Fletton
Wansford
Alwalton
Orton Longville
Waterville
Chesterton
Eastrea
Old Nen R.
SHELLY GRAVEL AT MARCH
11
March
80
Farcet
Haddon
Morborn
Yaxley
13
Stilton
Holme
Glatton
Whittlesea Mere
FENLAND
Ramsey Mere
Benwick
Stonea Sta.
Welney
Manea
Doddington
Oundle
13
Barnwell
Conington
Worlick
Ouse R.
PEAT DEPOSITS ON THE FENS WITH REMAINS OF BEAR, BEAVER, &c.
BOULDER CLAY WITH TRANSPORTED MASS

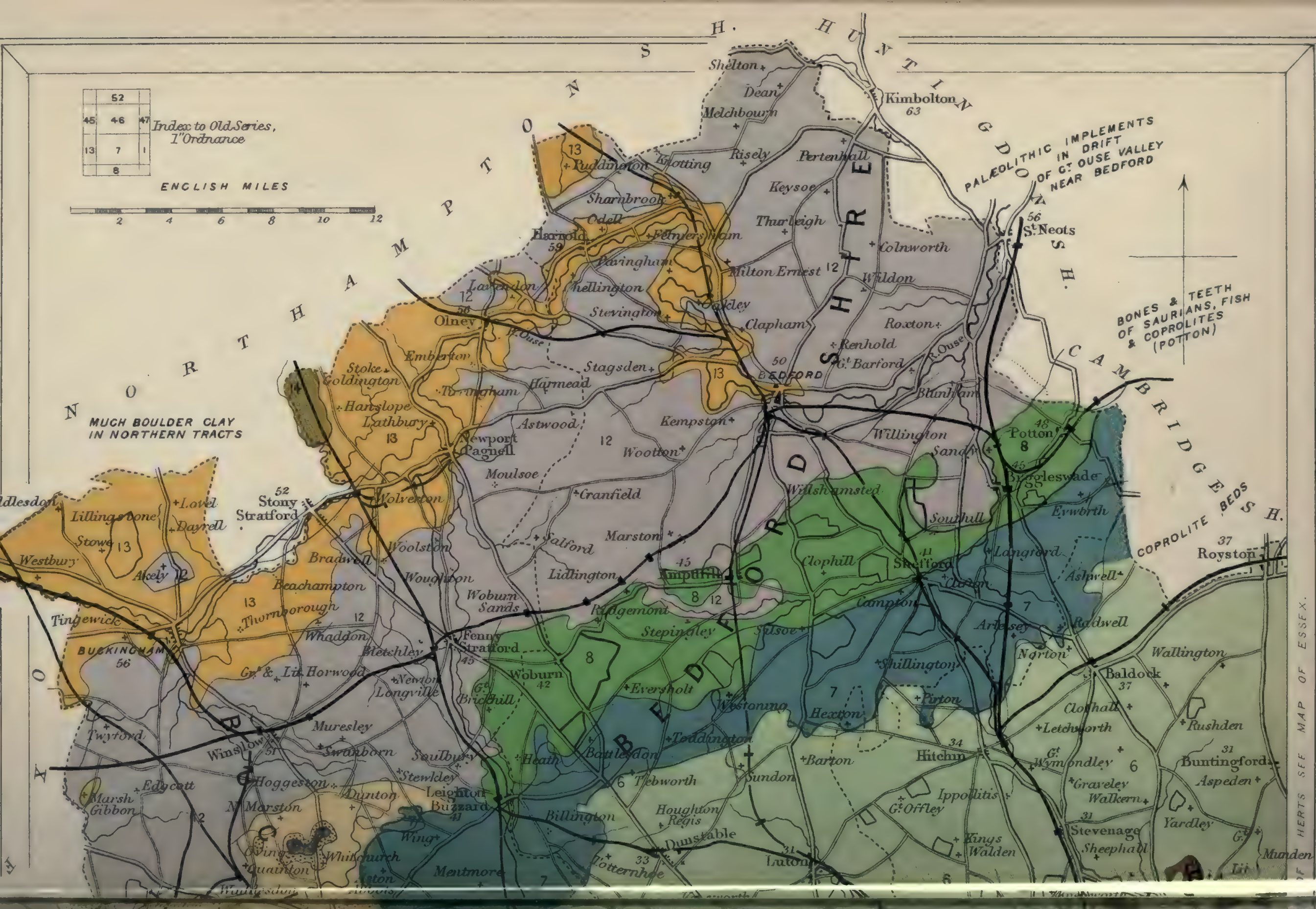


HIPPOPOTAMUS, BOS, &c. IN THE BARNWELL GRAVELS, CAMBRIDGE.
PHOSPHATIC DEPOSITS (COPROLITES) WITH REMAINS OF REPTILES, FISH, &c. IN THE CAMBRIDGE GREENSAND
BOULDER CLAY
BOULDER CLAY IN ISOLATED PATCHES
PART OF SUFFOLK
HUNTS. DET.
BEDFORD SH.
HERTFORD SH.
ESSEX
SUFFOLK
HUNTINGDON
CAMBRIDGE
ELY
Newmarket
St. Neots
St. Ives
Royston
Haverhill
Mildenhall
Cam R.
Ouse R.



OXFORDSHIRE
AND
BERKSHIRE.
Index to New Series, 1" Ordnance
201 Banbury
217 Chipping Norton 218 219
235 236 Oxford 237 Thame
252 Abingdon 253 254 Henley 255
Hungerford 267 268 269 Windsor Reading
283
ENGLISH MILES
2 4 6 8 10 12
Index to Old Series, 1" Ordnance
53
44 45
34 13 7
12 8
NORTHAMPTON SH.
WARWICK SH.
BUCK
55 BUCKINGHAM
IRON ORE
Kings Sutton
FOSSILIFEROUS BEDS
AMMONITES IN OXFORD CLAY
CORALLIAN BEDS AT WHEATLEY, FARINGDON &c.
MAMMOTH, RHINOCEROS, &c. IN THAMES VALLEY GRAVEL.
Shipston on Stour
Claydon
Mollington
Cropredy
Hornton
Wardington
Hanwell
Wroxton
Epwell
Shutford
BANBURY
Swalcliffe
Tadmarton
Broughton
Bodicott
Bloxham
Adderbury
Barford
Hook Norton
Newington
Deddington
Over Worton
Dunstew
Souldern
Hardwicke
Hethe
Shells Well
Fincmere
Newton Purcell
Stoke Lyne
Stratton Audley
Ardley
Heyford
Bicester
Launton
Middleton Stoney
Wendlebury
Kirtlington
Merton
Ambrosden
Bletchingdon
Hampton Poyle
Islip
Charlton on Moor
Wood Eaton
Beckley
Elsfield
Marston
Stanton St. John
OXFORD
Begbroke
Bladon
Blenheim Park
WOODSTOCK
Stonesfield
Charlbury
Wilcote
Church Handboro
Wolvercot
S. Leigh
Eynsham
Ducklington
Cogges
Witney
Minster Lovell
Burford
Fulbrook
Taynton
Swinbrook
Shipton
Ascott
Idbury
Shorthampton
Spelsbury
Chadlington
Sarsden
Kingham
Chipping Norton
Enstone
Kiddington
Over Worton
Wescott Barton
Westcott Barton
Aston
G. Tew
Rollright
Swerford
Salford
Chastleton
Holwell
Aylesbury


MAMMOTH, REINDEER, BISON &c. IN DRIFT AT DIDCOT
SPONGE GRAVELS, (FOSSIL SPONGES &c) AT COXWELL, FARINGDON
SHELL BED WITH CYRENA NEAR NEWBURY & AT CASTLE HILL READING
PALÆOLITHIC IMPLEMENTS, MAMMOTH, RHINOCEROS, &c. IN SAND & GRAVEL NEAR READING
PLANTS IN READING BEDS (Lower Eocene)
BERKSHIRE
WALLINGFORD
GREAT MARLOW
WINDSOR
Princes Risborough
Stoken Church
Ibstone
Taplow
Maidenhead
Cookham
Henley upon Thames
Wantage
Faringdon
Lambourn
Hungerford
Newbury
Wokingham
Didcot
Steventon
Harwell
Abingdon
Shalbourn
To Basingstoke

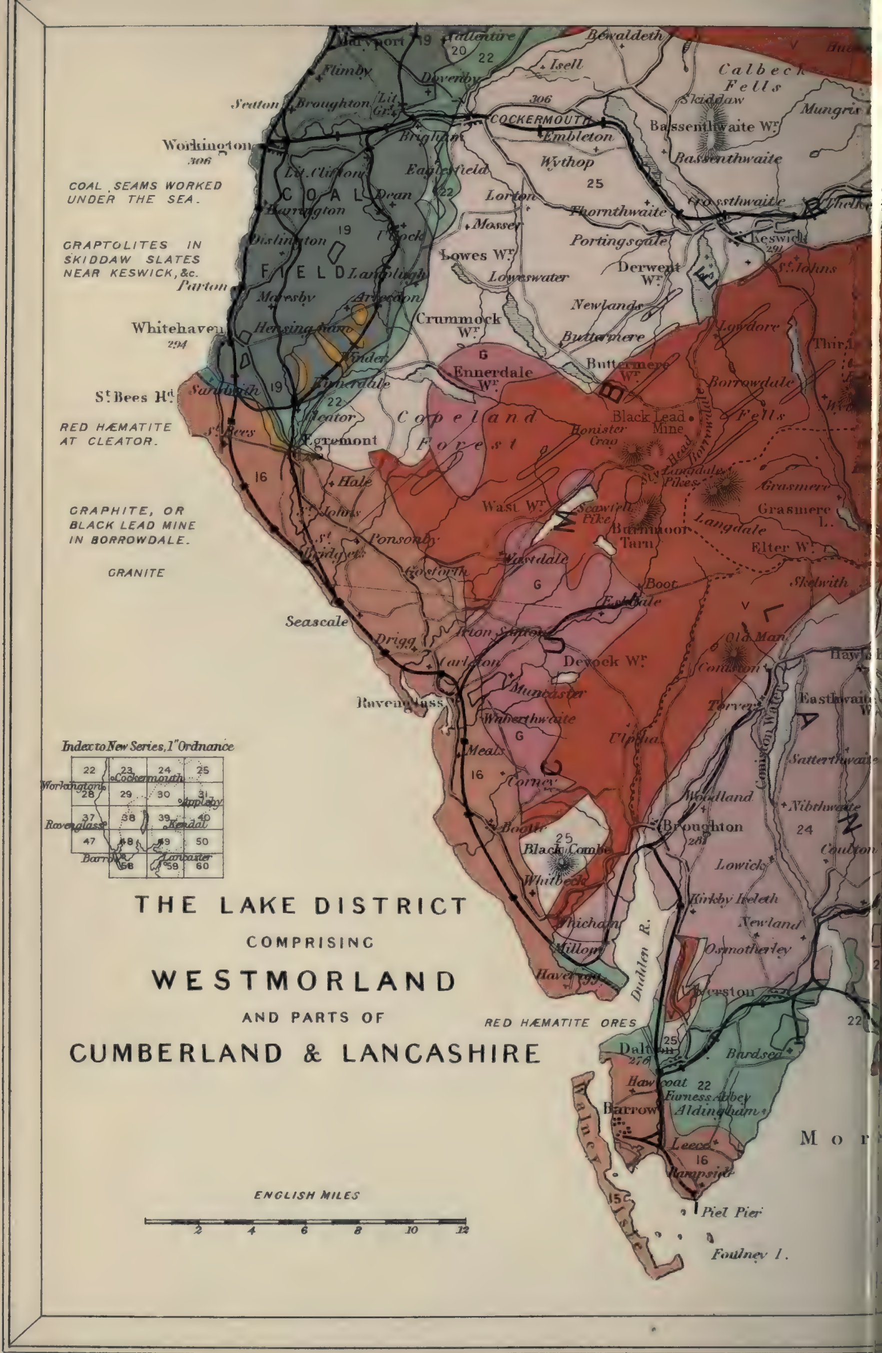


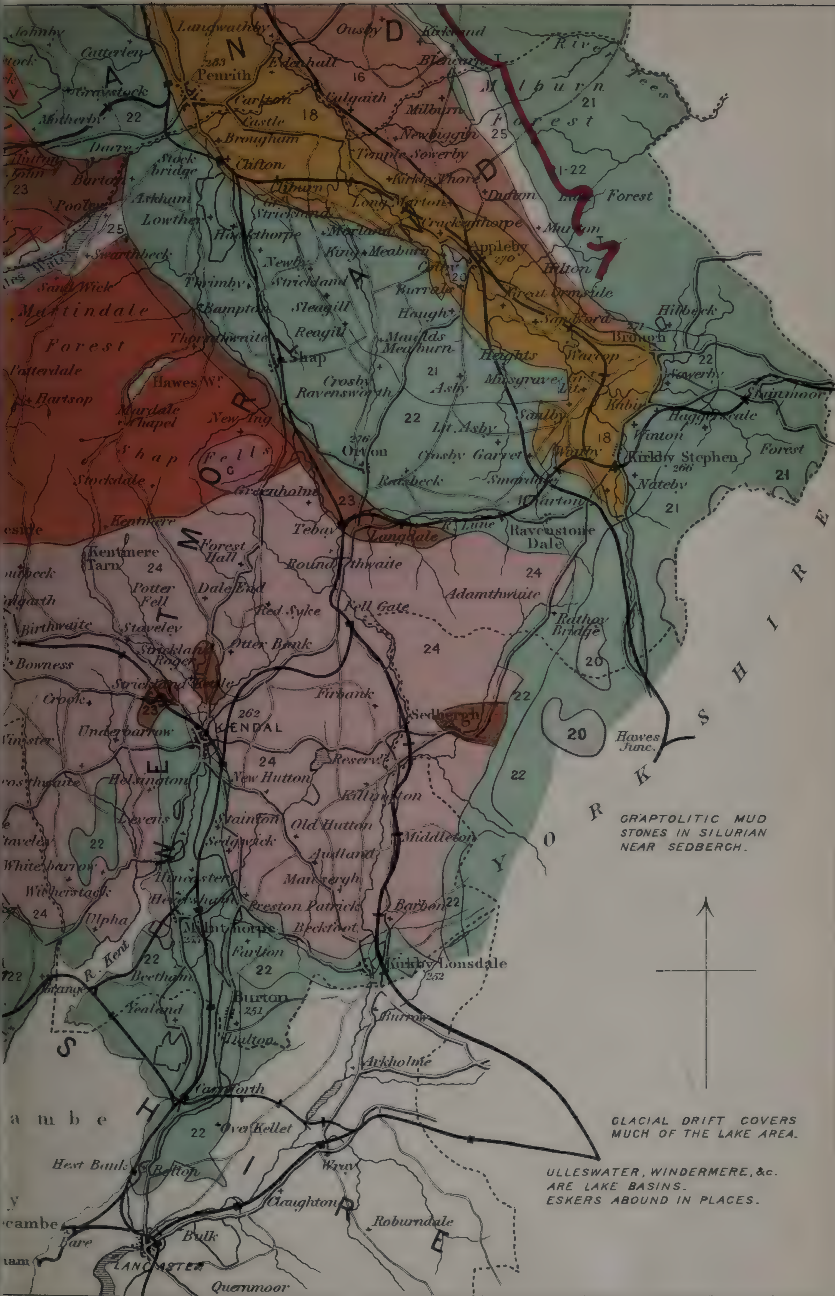
Index to Old Series, 1" Ordnance
ENGLISH MILES
MUCH BOULDER CLAY IN NORTHERN TRACTS
PALÆOLITHIC IMPLEMENTS IN DRIFT OF Gt OUSE VALLEY NEAR BEDFORD
BONES & TEETH OF SAURIANS, FISH & COPROLITES (POTTON)
COPROLITE BEDS
NORTHAMPTONSH.
HUNTINGDONSH.
CAMBRIDGESH.
BEDFORDSHIRE
OF HERTS SEE MAP OF ESSEX.
Bedford
Kimbolton
St. Neots
Royston
Stony Stratford
Buckingham
Newport Pagnell
Olney
Woburn
Ampthill
Shefford
Biggleswade
Potton
Leighton Buzzard
Dunstable
Luton
Hitchin
Baldock
Stevenage
Buntingford
Winslow
Fenny Stratford
Bletchley
Wolverton

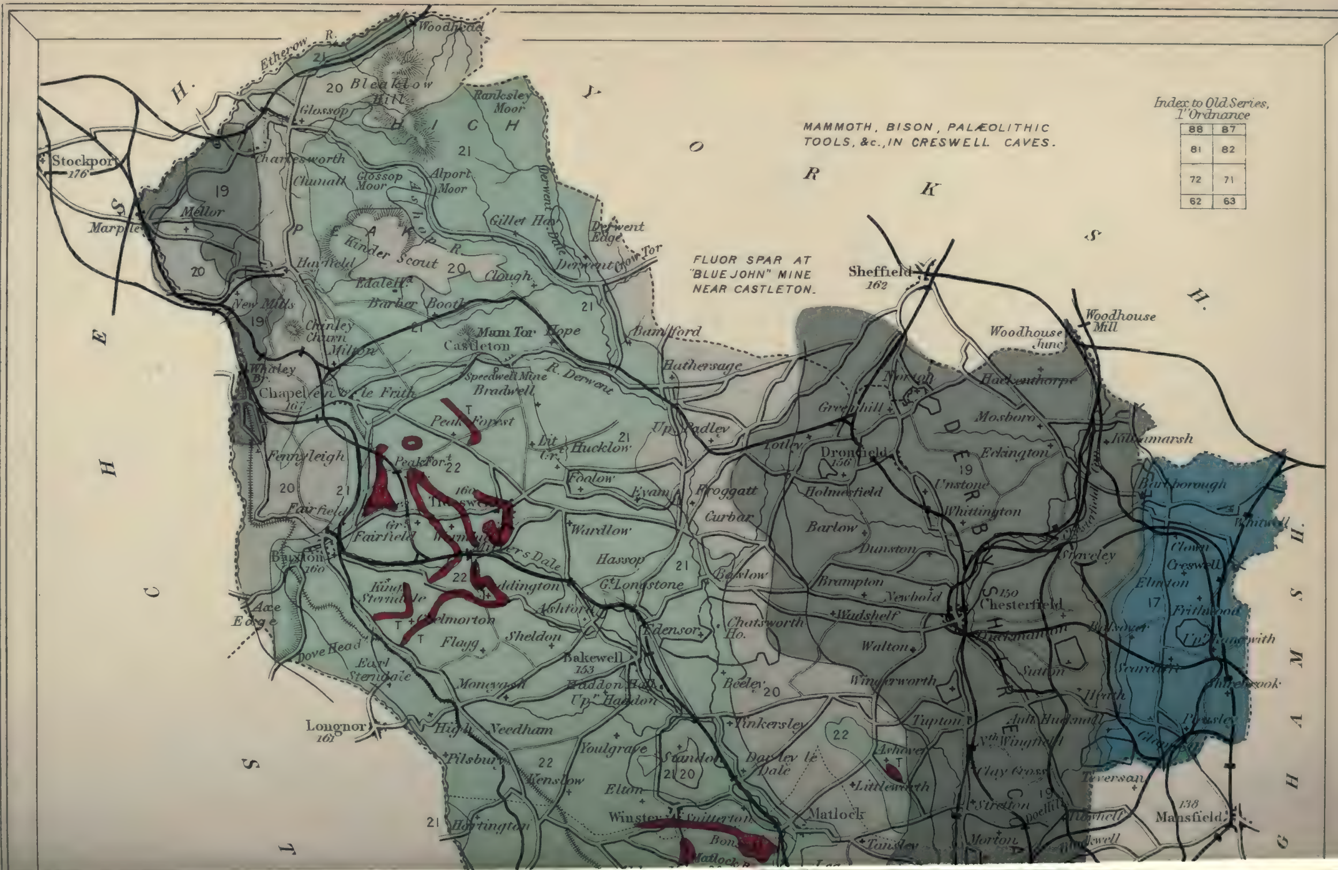
London : Edward Stanford, 12, 13 & 14, Long Acre, W.C.


ISLE OF MAN
2 4 6 MILES
Pt. of Ayre
Rue Pt.
Cranstal
Ballathona
Bride
Johneios
Andreas
Ramsey Bay
Jurby Hd.
Jurby
Sandygate
Seaview
The Curragh
Sulby
RAMSEY
Ballaugh
Kirk Christ Lezayre
Maughold Hd.
Kirk Maughold
N. Barrule
Kirk Michael
Dhoon
Snae Fell
RED SANDSTONE AND CONGLOMERATE
Ballybavre
Kinskoe
LEAD MINE.
Laxey
Castle
Kirk St. Germain
Kirk Lonan
PEEL
Contrary Hd.
Clay Head
Kirk Patrick
Kirk Marown
Onchan
Kirk Braddan
Banks How
S. Barrule
Foxdale
DOUGLAS
Ballnahovin
Balla Tear
Balna Killa
Douglas Hd.
Ballasarkish
Kirk Santon
Ballasalla
Kirk Arbory
Colby
St. Anns Hd.
Derby Haven
Breda Hd.
P. Erin
Kirk Christ Rushen
Kirk Malew
CASTLETOWN
Poolvash Bay
Kitterland
Scarlet Pt.
Langness Pt.
Calf of Man
Spanish Hd.
Annan
Gretna
Springfield
R. Esk
R. Eden
SOLWAY FIRTH
Bowness
Cardurnock
Anthorn
Drumburgh Cas.
Beaumont
Burgh
SUBMERGED FOREST
Kirkbride
Fingland
Skinburness
Silloth
Hardow
Gamblesby
Aikton
Blitter Lees
Oulton
Abbey Holme or Holm Cultram
Wigton
Thursby
Dalston
Moorthwaite
Bromfield
Waverton
Old Carlisle
Mealrigg
Longrigg
W. Newton
Westward
Allonby
Brayton
Aspatria
Allhallows
Hayton
Bolton
Sebergham
Allerby
Bothel
Caldbeck
Cross Canonby
Ireby
Plumbland
Hesket Newmarket
Maryport
High Ireby
Gilcrux
Caldbeck
Index to New Series, 1" Ordnance
Longtown
Carlisle
Maryport
Isle of Man, Pub. in 1 Sht.

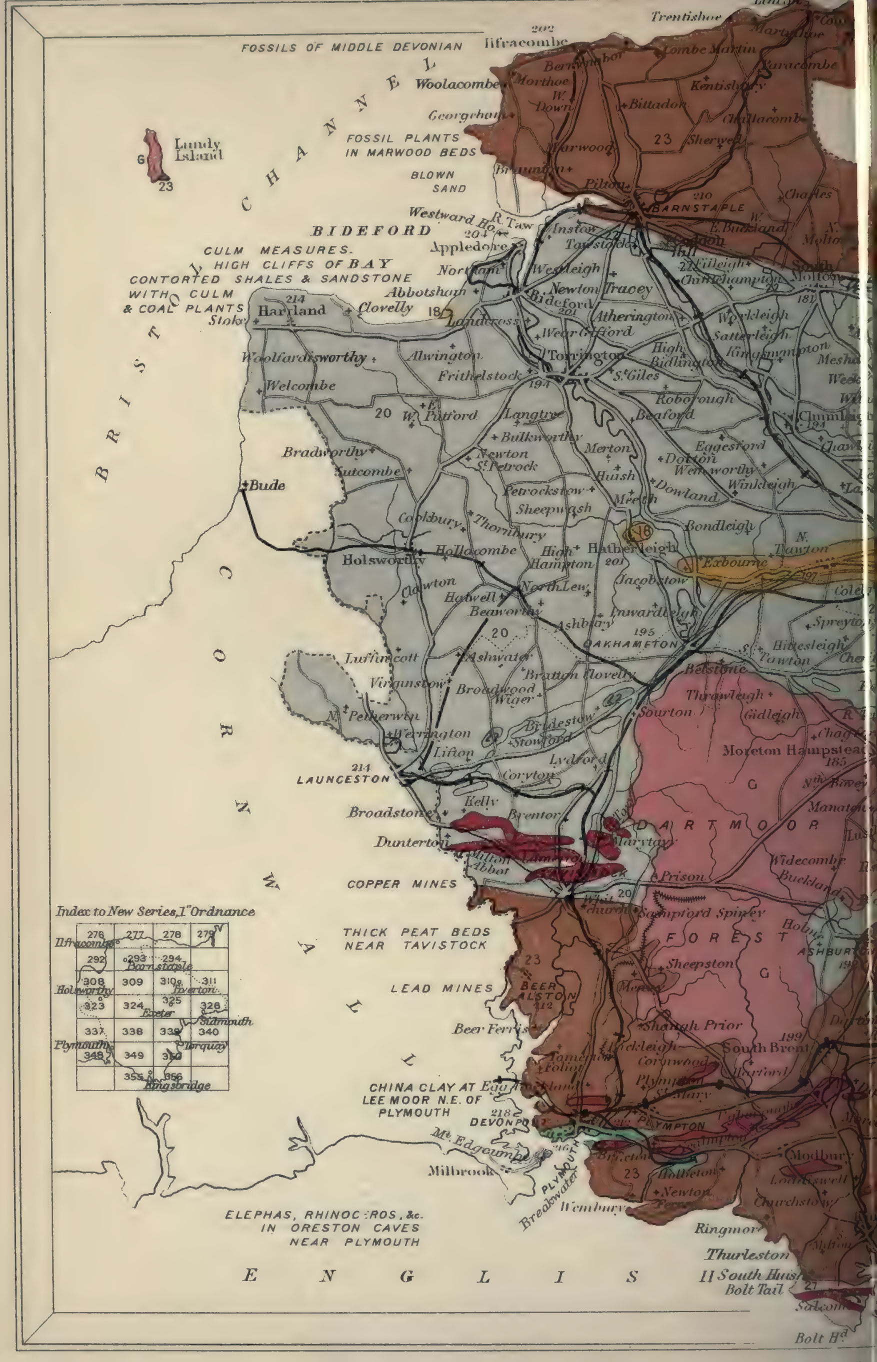
3 & 14 Long Acre, W.C.

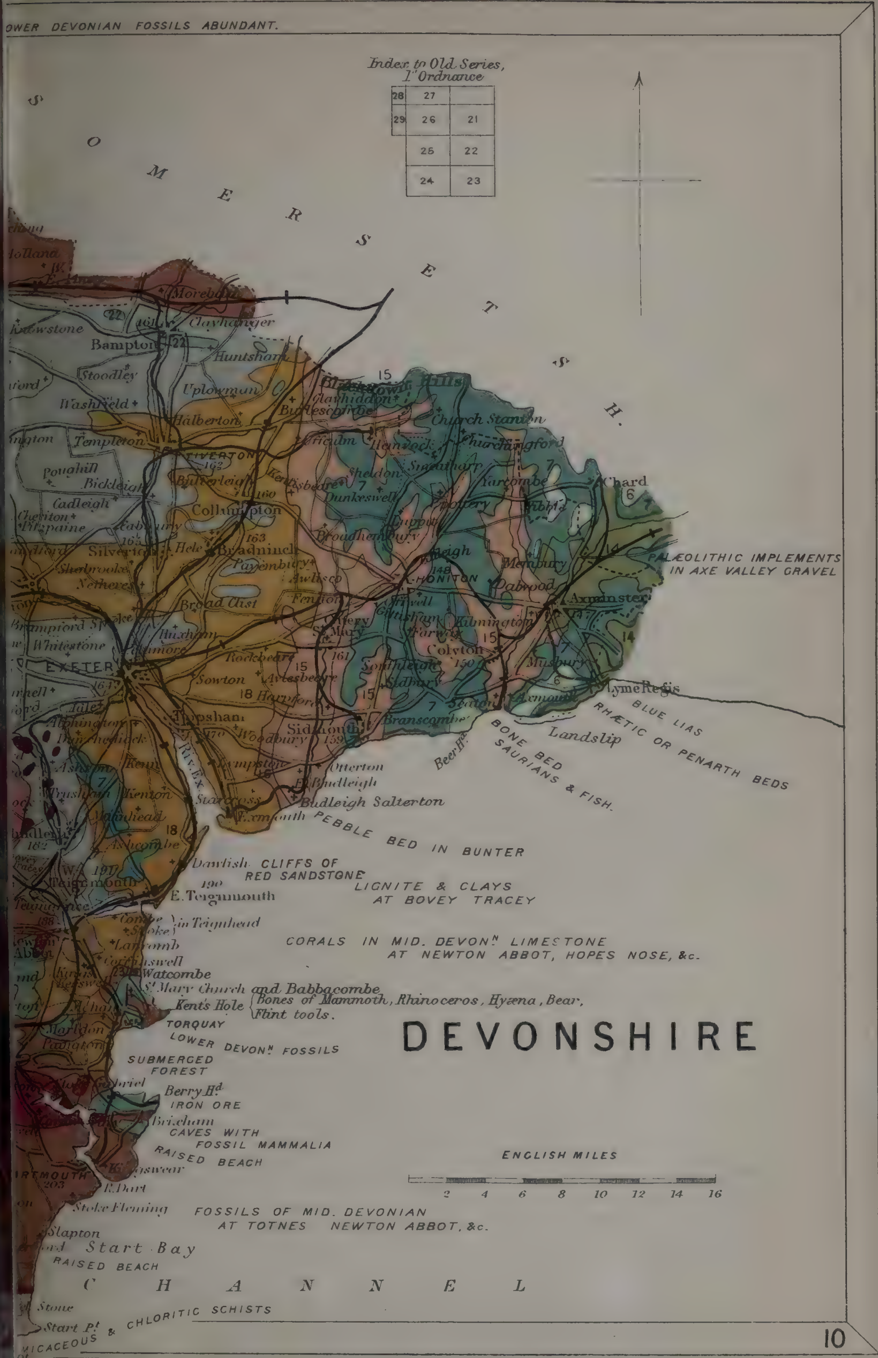

THE LAKE DISTRICT
COMPRISING
WESTMORLAND
AND PARTS OF
CUMBERLAND & LANCASHIRE
COAL SEAMS WORKED UNDER THE SEA.
GRAPTOLITES IN SKIDDAW SLATES NEAR KESWICK, &c.
RED HÆMATITE AT CLEATOR.
GRAPHITE, OR BLACK LEAD MINE IN BORROWDALE.
GRANITE
RED HÆMATITE ORES
Index to New Series, 1" Ordnance
ENGLISH MILES
2 4 6 8 10 12
COAL FIELD
Copeland Forest
Maryport
Flimby
Seaton
Broughton
Workington
Cockermouth
Embleton
Wythop
Bassenthwaite
Calbeck Fells
Skiddaw
Keswick
Lorton
Mosser
Lowes Wr.
Loweswater
Portingscale
Thornthwaite
Derwent Wr.
Newlands
Crummock Wr.
Buttermere
Ennerdale Wr.
Whitehaven
Parton
Moresby
Lamplugh
Harrington
Distington
Egremont
Cleator
St. Bees Hd.
St. Bees
Black Lead Mine
Honister Crag
Borrowdale Fells
Lowdore
Langdale Pikes
Grasmere
Grasmere L.
Langdale
Elter Wr.
Skelwith
Scawfell Pike
Burnmoor Tarn
Wastdale
Wast Wr.
Boot
Eskdale
Gosforth
Ponsonby
Seascale
Drigg
Irton
Carleton
Ravenglass
Muncaster
Devock Wr.
Old Man
Coniston
Torver
Ulpha
Waberthwaite
Corney
Bootle
Black Combe
Whitbeck
Whicham
Millom
Haverigg
Duddon R.
Broughton
Woodland
Lowick
Kirkby Ireleth
Newland
Osmotherley
Satterthwaite
Nibthwaite
Coniston Water
Dalton
Hawcoat
Furness Abbey
Aldingham
Bardsea
Barrow
Leece
Rampside
Piel Pier
Foulney I.
Walney Isle


GRAPTOLITIC MUD STONES IN SILURIAN NEAR SEDBERGH.
GLACIAL DRIFT COVERS MUCH OF THE LAKE AREA.
ULLESWATER, WINDERMERE, &c. ARE LAKE BASINS.
ESKERS ABOUND IN PLACES.
WESTMORLAND
YORKSHIRE
Penrith
Appleby
Kirkby Stephen
Shap
Tebay
Kendal
Sedbergh
Kirkby Lonsdale
Milnthorpe
Carnforth
Lancaster
Brough
Orton
Ravenstone Dale
Hawes Junc.
Martindale Forest
Shap Fells
Stainmoor Forest
Milburn Forest
Hawes W.
Bowness
Burton
Arkholme
Over Kellet
Claughton
Quernmoor
Roburndale
Morecambe


MAMMOTH, BISON, PALÆOLITHIC TOOLS, &c., IN CRESWELL CAVES.
FLUOR SPAR AT "BLUE JOHN" MINE NEAR CASTLETON.
Index to Old Series, 1" Ordnance
88 87
81 82
72 71
62 63
YORKSH.
CHESH.
STAFFS
NOTTINGHAMSH.
DERBYSHIRE
HIGH PEAK
Sheffield 162
Stockport 176
Chesterfield 150
Mansfield 138
Longnor 161
Matlock
Bakewell 153
Buxton 160
Castleton
Mam Tor
Kinder Scout
Bleaklow Hill
Glossop
Woodhead
Marple
Mellor
New Mills
Chapel en le Frith
Hathersage
Bamford
Woodhouse Mill
Woodhouse Junc.
Creswell
Whitwell
Barlborough
Killamarsh
Eckington
Dronfield
Staveley
Tideswell
Peak Forest
Bradwell
Hope
Eyam
Froggatt
Curbar
Baslow
Chatsworth Ho.
Edensor
Beeley
Darley le Dale
Winster
Youlgrave
Hartington
Elton
Hassop
Wardlow
Great Longstone
Ashford
Sheldon
Flagg
Chelmorton
Tinkersley
Tansley
Wingerworth
Tupton
Clay Cross
Teversal
Elmton
Clown


DERBYSHIRE
MAMMOTH, &c. IN DRIFT NEAR ASHBOURNE.
GYPSUM GREATLY WORKED AT CHELLASTON.
Index to New Series, 1" Ordnance
86
99
100
111
112
124
125
140
141
154
155
Chapel en le Frith
Chesterfield
Wirksworth
Derby
Burton
ENGLISH MILES
2
4
6
8
10
DERBY
Uttoxeter
135
Burton upon Trent
125
Ashby de la Zouch
115
Loughborough
Castle Donington
Donington Park
Long Eaton
NOTTINGHAM
124
Trowell
Belper
134
Ashbourne
139
Mappleton
Tutbury
Alrewas
Ravenstone
Measham
Eye Br.
Dale
Tissington
Bradbourne
Hognaston
Kirk Ireton
Shottle
Kniveton
Atlow
Turnditch
Hazelwood
Duffield
Heanor
Denby
Smalley
Horsley
Morley
Ilkeston
Stanton
Dale Abbey
Chaddesden
Spondon
Ockbrook
Risley
Borrowash
Breaston
Elvaston
Shardlow
Aston
Weston
Melbourne
Ticknall
Stanton
Repton
Foremark
Newton Solney
Bradby
Hartshorn
Swadlincote
Woodville
Smisby
Church Gresley
Caldwell
Walton
Rosliston
Croxhall
Lullington
Edingale
Stretton
Chilcote
Willesley
Egginton
Willington
Marston
Scropton
Sudbury
Doveridge
Somersal Herbert
Marston Montgomery
Norbury
Snelston
Bradley
Edlaston
Osmaston
Shirley
Brailsford
Mugginton
Kedleston
Allestree
Kirk Langley
Longford
Cubley
Radburn
Mackworth
Trusley
Barton Blount
Sutton
Church Broughton
Dalbury
Mickleover
Littleover
Normanton
Findern
Etwall
Chellaston
Barrow
Swarkeston
Whittenly
Rodstone
Derwent R.
R. Trent
R. Mease
Dove R.
Derby Can.
Erewash Can.
London: Edward Stanford, 12, 13 & 14, Long Acre, W.C.
9


FOSSILS OF MIDDLE DEVONIAN
BRISTOL CHANNEL
Lundy Island
FOSSIL PLANTS IN MARWOOD BEDS
BLOWN SAND
BIDEFORD
CULM MEASURES.
HIGH CLIFFS OF BAY
CONTORTED SHALES & SANDSTONE WITH CULM & COAL PLANTS
Ilfracombe
Woolacombe
Barnstaple
Bude
Holsworthy
Hatherleigh
Okehampton
Launceston
Tavistock
DARTMOOR FOREST
Moreton Hampstead
COPPER MINES
THICK PEAT BEDS NEAR TAVISTOCK
LEAD MINES
CHINA CLAY AT Egg Buckland
LEE MOOR N.E. OF PLYMOUTH
CORNWALL
Index to New Series, 1" Ordnance
Plymouth
Devonport
Plympton
Mt. Edgcumbe
Plymouth Breakwater
ELEPHAS, RHINOCEROS, &c. IN ORESTON CAVES NEAR PLYMOUTH
ENGLISH
Bolt Tail
Bolt Hd



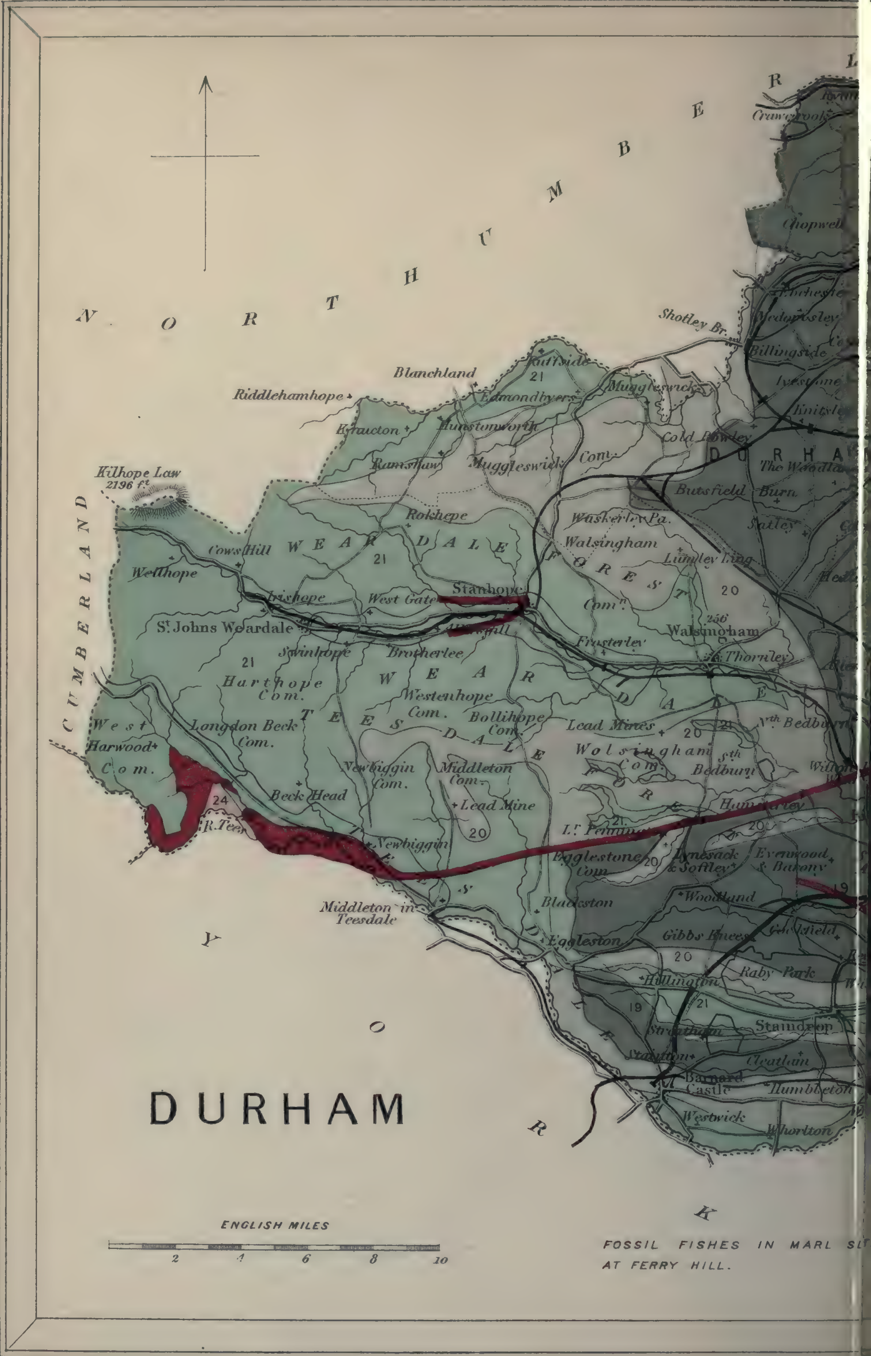
OWER DEVONIAN FOSSILS ABUNDANT.
Index to Old Series, 1" Ordnance
28 27
29 26 21
25 22
24 23
SOMERSET SH.
Bampton
Clayhanger
Huntsham
Uplowman
Halberton
Templeton
TIVERTON
Bickleigh
Cadleigh
Collumpton
Silverton
Bradninch
Payembury
Broad Clist
Blackdown Hills
Church Stanton
Churchingford
Dunkeswell
Yarcombe
Chard
Membury
Dalwood
HONITON
Axminster
Kilmington
Colyton
Musbury
Ottery St Mary
Gittisham
Farway
Southleigh
Sidbury
Seaton
Branscombe
Beer Hd
Lyme Regis
PALÆOLITHIC IMPLEMENTS IN AXE VALLEY GRAVEL
BLUE LIAS
RHÆTIC OR PENARTH BEDS
BONE BED SAURIANS & FISH.
Landslip
EXETER
Whitestone
Rockbeare
Sowton
Aylesbeare
Harpford
Topsham
Woodbury
Sidmouth
Lympstone
Otterton
E. Budleigh
Budleigh Salterton
Starcross
Exmouth
PEBBLE BED IN BUNTER
Kenton
Mamhead
Ashcombe
Dawlish
CLIFFS OF RED SANDSTONE
Teignmouth
E. Teignmouth
LIGNITE & CLAYS AT BOVEY TRACEY
Combe in Teignhead
Stoke
CORALS IN MID. DEVONN LIMESTONE AT NEWTON ABBOT, HOPES NOSE, &c.
Watcombe
St Mary Church and Babbacombe
Kent's Hole
Bones of Mammoth, Rhinoceros, Hyæna, Bear, Flint tools.
TORQUAY
LOWER DEVONN FOSSILS
DEVONSHIRE
Paignton
SUBMERGED FOREST
Berry Hd
IRON ORE
Brixham
CAVES WITH FOSSIL MAMMALIA
RAISED BEACH
ENGLISH MILES
2 4 6 8 10 12 14 16
DARTMOUTH
Kingswear
Stoke Fleming
FOSSILS OF MID. DEVONIAN AT TOTNES NEWTON ABBOT, &c.
Slapton
Start Bay
RAISED BEACH
CHANNEL
Start Pt
CHLORITIC SCHISTS
MICACEOUS

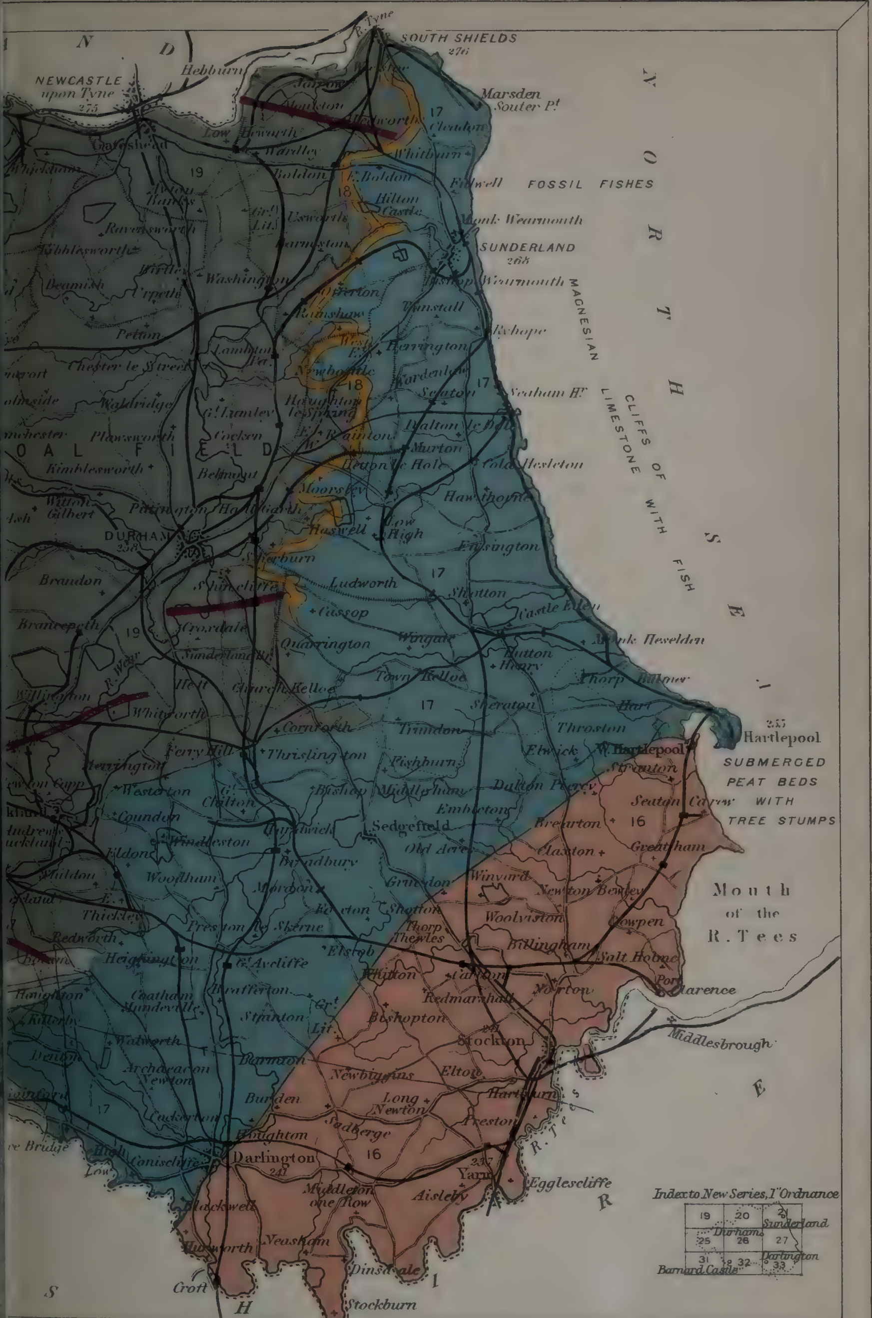
DORSETSHIRE, SOMERSETSHIRE

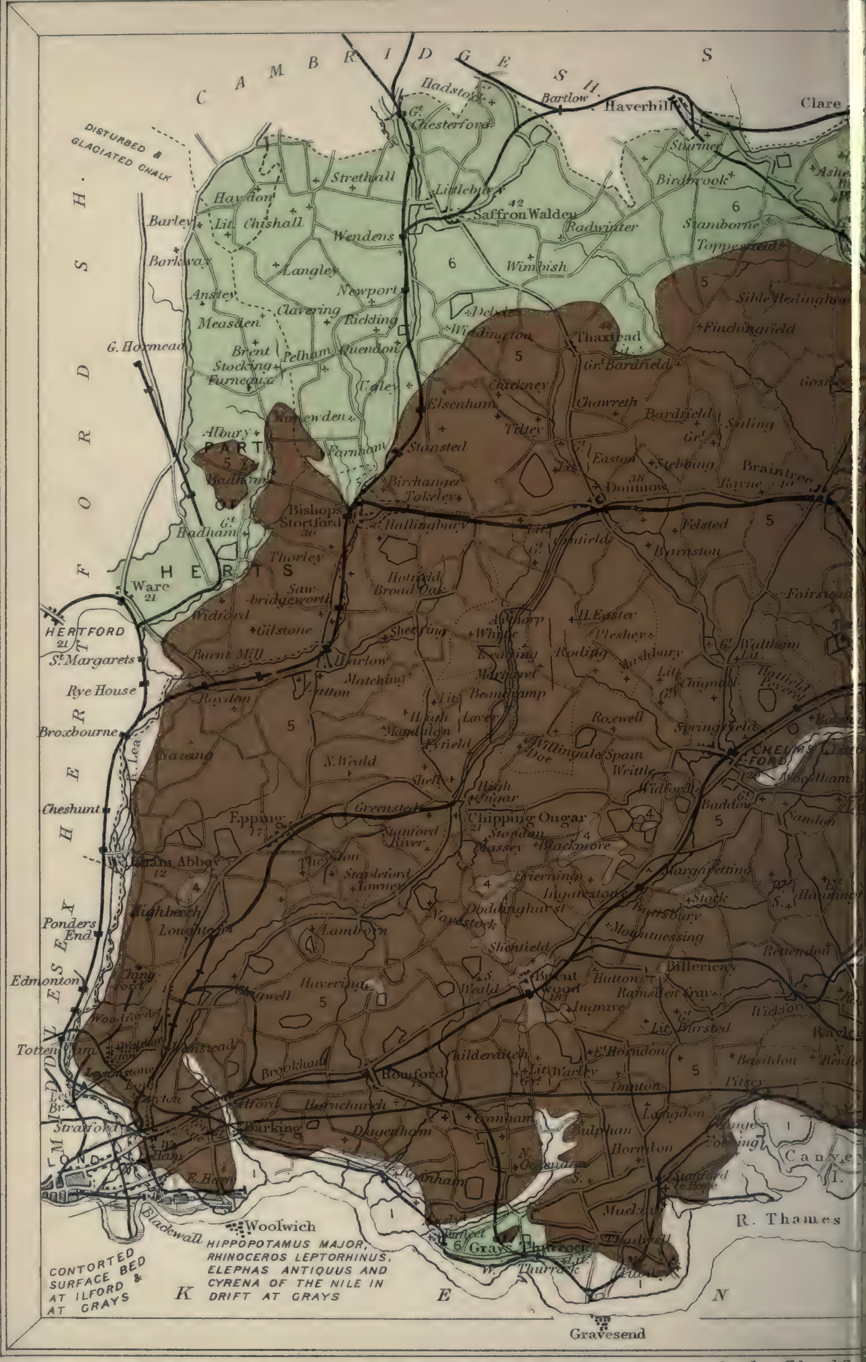
AND

SOUTH WILTSHIRE.

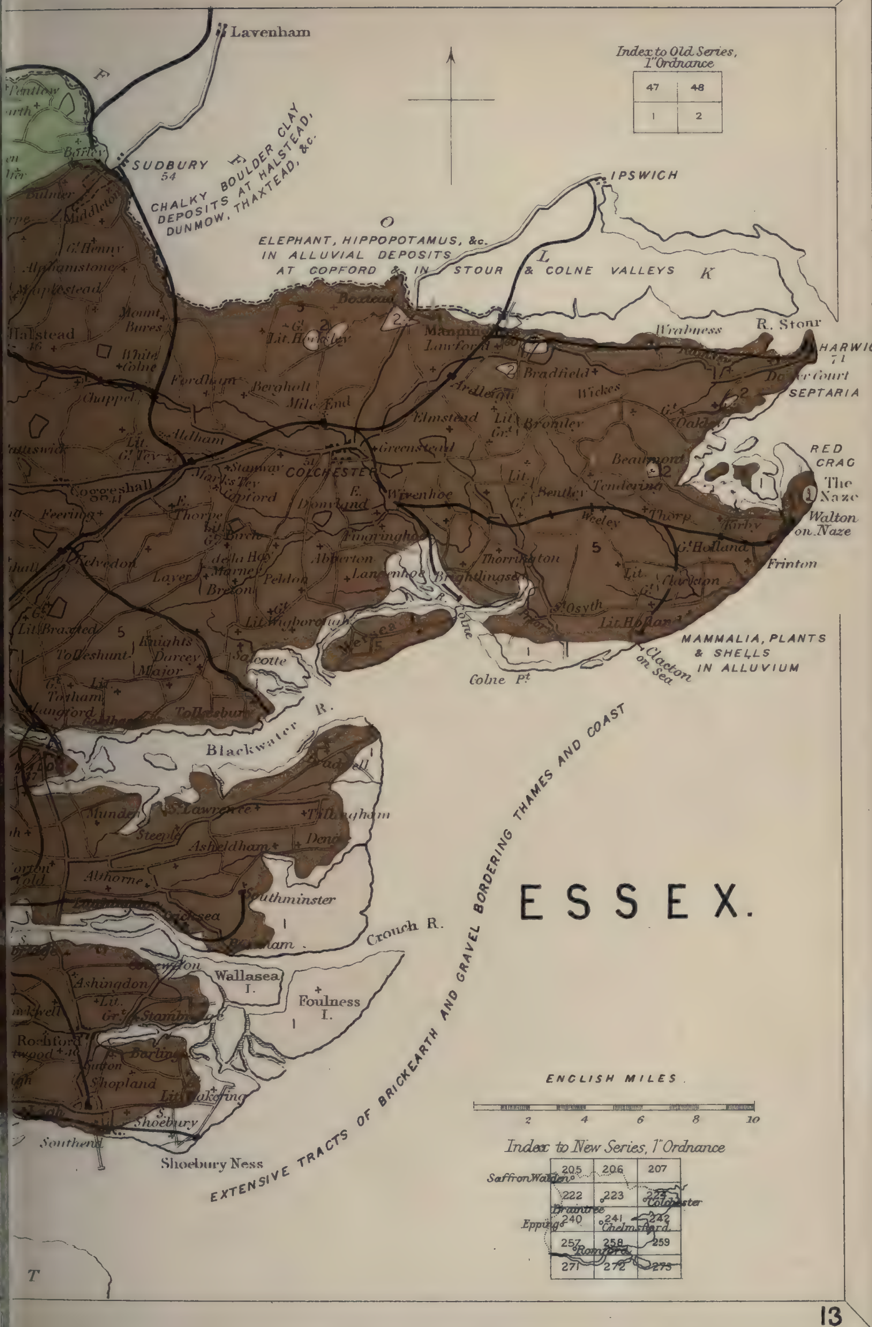

FOSSIL SPONGES & MOLLUSCA IN UPPER GREENSAND NEAR WARMINSTER
CORALS & CRINOIDEANS
WELL PRESERVED FOSSIL PLANTS IN RADSTOCK COAL MEASURES
BRISTOL
BATH
BRADFORD
Devizes
Westbury
Warminster
HEYTESBURY
Frome
SALISBURY PLAIN
Amesbury
Stonehenge
Ludgershall
Tidworth
Hungerford
WILTON
SALISBURY
Shaftesbury
Gillingham
Wincanton
Bruton
Sherborne
MILBORNE PORT
Stalbridge
Sturminster Newton
Blandford Forum
Wimborne Minster
Fordingbridge
Ringwood
Christchurch
Bournemouth
Poole
Poole Hr.
WAREHAM
Dorchester
Weymouth
MELCOMBE REGIS
Portland Road
Breakwater
Portland Isle
Portland Bill
Abbotsbury
Chesil Bank
Lulworth Cove
Corfe Castle
Swanage
Studland
St. Albans Hd.
W I L T S H
S. W I L T S H.
S E T S H I R E
H A M P S H
C H A N N E L
FOSSIL PLANTS
POTTERY CLAYS
ISLE OF PURBECK
CHALK WITH FLINTS NEARLY VERTICAL
REPTILIAN REMAINS
MARSUPIAL MAMMALIA IN PURBECK BEDS
BEDS OF LIMESTONE WITH LARGE AMMONITES.
KIMERIDGE CLAY CLIFFS
DIRT BED
RAISED BEACH
KIMERIDGE CLAY
PURBECK AND PORTLAND FOSSILS
11


NORTHUMBERLAND
CUMBERLAND
YORK
DURHAM
Kilhope Law
2196 ft.
Riddlehamhope
Blanchland
Ruffside
Edmondbyers
Muggleswick
Shotley Br.
Hunstonworth
Ramshaw
Muggleswick Com.
Cold Rowley
Rokhope
Cows Hill
WEAR DALE
Wellhope
West Gate
Stanhope
Waskerley Pa.
Walsingham
FOREST
Lumley Ling
Comn.
Walsingham
Frosterley
Thornley
St. Johns Weardale
Swinhope
Brotherlee
WEAR
DALE
Harthope Com.
Westenhope Com.
Bollihope Com.
TEES DALE
Longdon Beck Com.
West Harwood Com.
Lead Mines
Wolsingham Com.
FORE
Sth Bedburn
Nth Bedburn
Newbiggin Com.
Middleton Com.
Lead Mine
Beck Head
R. Tees
Newbiggin
Lt. Pennington
Eggleston Com.
Lynesack & Softley
Evenwood & Barony
Woodland
Middleton in Teesdale
Blackston
Eggleston
Gibbs Knees
Raby Park
Hillington
Streatlam
Staindrop
Cleatlam
Barnard Castle
Humbleton
Westwick
Whorlton
Chopwell
Billingside
Butsfield Burn
Satley
Crawcrook
DURHAM
Walsingham
Humsterley
ENGLISH MILES
2
4
6
8
10
FOSSIL FISHES IN MARL SL
AT FERRY HILL.

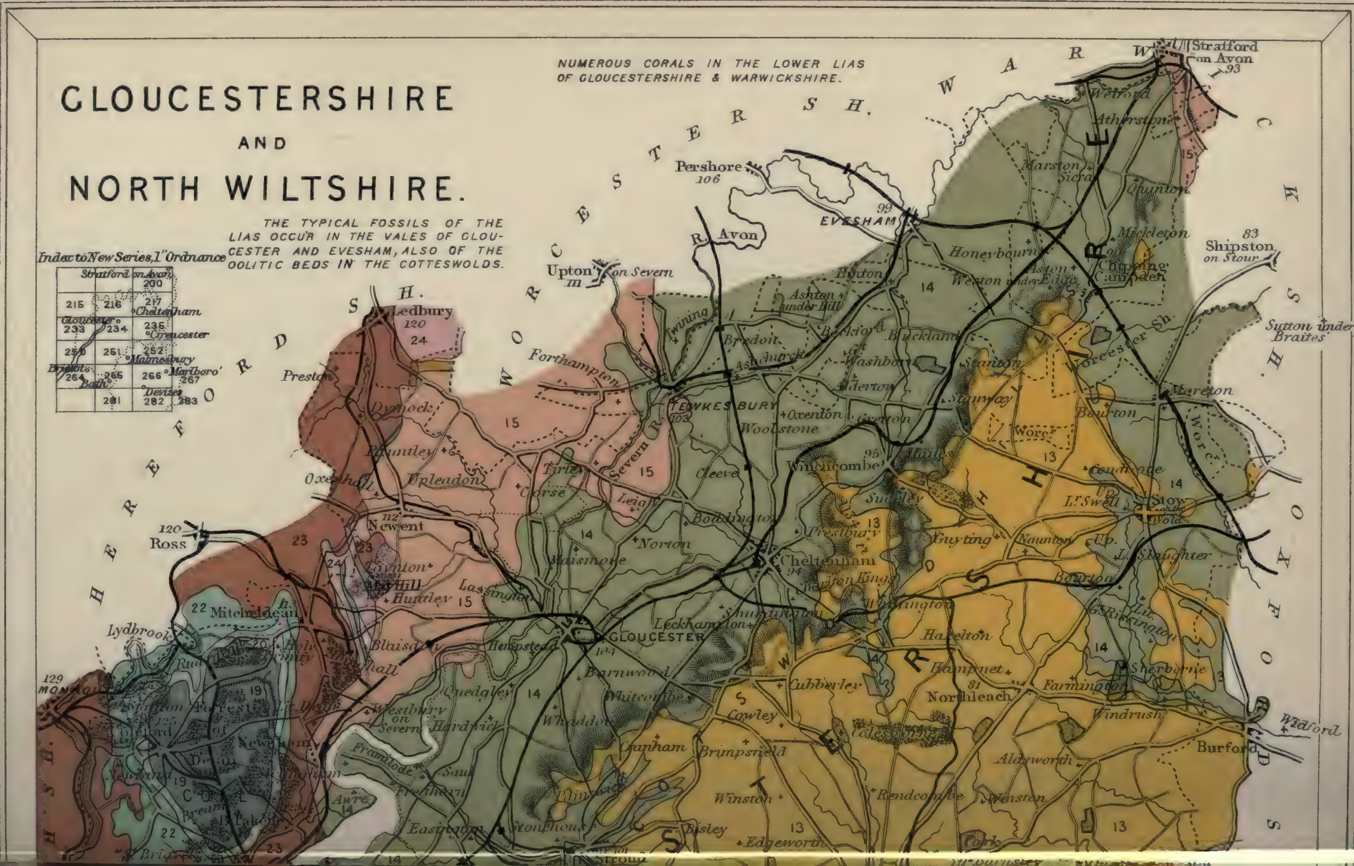

R. Tyne
SOUTH SHIELDS
276
NEWCASTLE upon Tyne
275
Hebburn
Jarrow
Gateshead
Marsden
Souter Pt
Cleadon
Whitburn
Boldon
Fulwell
FOSSIL FISHES
Hilton Castle
Monk Wearmouth
SUNDERLAND
268
Bishop Wearmouth
MAGNESIAN LIMESTONE
CLIFFS OF LIMESTONE WITH FISH
NORTH SEA
Washington
Beamish
Tunstall
Ryhope
Herrington
Chester le Street
Seaton
Seaham Hr
Houghton le Spring
Dalton le Dale
Murton
Cold Hesleton
Hawthorne
Haswell
Easington
DURHAM
258
Brandon
Ludworth
Shotton
Castle Eden
Cassop
Quarrington
Wingate
Monk Heselden
Brancepeth
Hutton Henry
Town Kelloe
Church Kelloe
Thorp Bulmer
Sheraton
Hart
Throston
Cornforth
Trimdon
255
Hartlepool
W. Hartlepool
SUBMERGED PEAT BEDS WITH TREE STUMPS
Stranton
Seaton Carew
Ferry Hill
Thrislington
Fishburn
Dalton Piercy
Embleton
Brearton
Greatham
Sedgefield
Claxton
Windleston
Bradbury
Old Acre
Newton Bewley
Mouth of the R. Tees
Wolviston
Cowpen
Billingham
Salt Holme
Port Clarence
Heighington
Gt Aycliffe
Norton
Redmarshall
Middlesbrough
Stockton
Elton
Hartburn
Long Newton
Preston
Sadberge
Darlington
241
Yarm
Egglescliffe
Middleton one Row
Aislaby
Blackwell
Neasham
Hurworth
Dinsdale
Croft
Stockburn
Index to New Series, 1" Ordnance
Sunderland
Durham
Darlington
Barnard Castle



CAMBRIDGESH.
HERTFORDSH.
HERTS
MIDDLESEX
KENT
DISTURBED & GLACIATED CHALK
CONTORTED SURFACE BED AT ILFORD & AT GRAYS
HIPPOPOTAMUS MAJOR, RHINOCEROS LEPTORHINUS, ELEPHAS ANTIQUUS AND CYRENA OF THE NILE IN DRIFT AT GRAYS
Saffron Walden
Haverhill
Bartlow
Clare
Thaxtead
Dunmow
Bishops Stortford
Chipping Ongar
Epping
Romford
Barking
Ilford
Woolwich
Blackwall
Gravesend
Grays Thurrock
Tilbury
R. Thames
Hertford
Ware
Cheshunt
Broxbourne
Edmonton
Tottenham
Billericay
Brentwood
Chelmsford
Braintree
Canvey I.



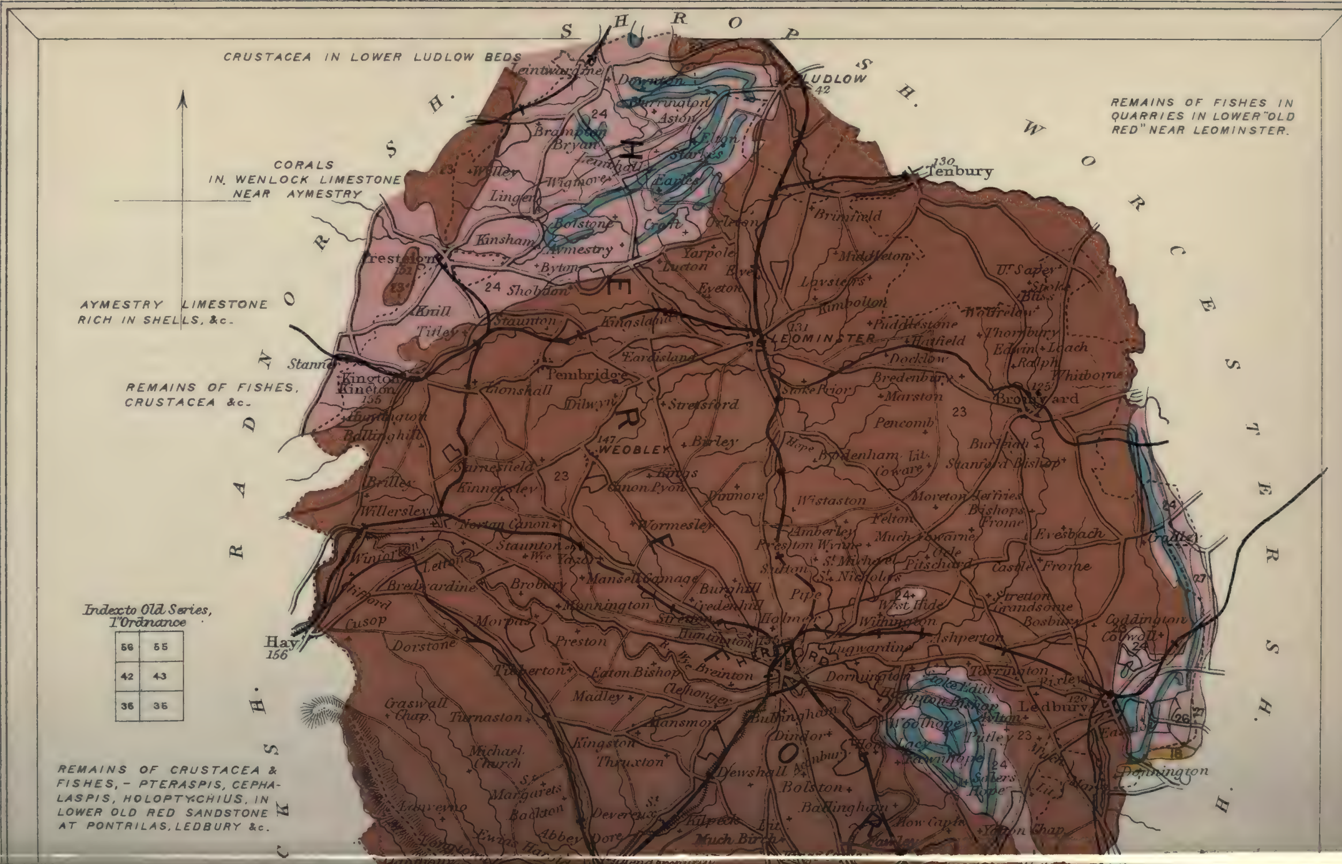
ESSEX.
Index to Old Series, 1" Ordnance
47 48
1 2
CHALKY BOULDER CLAY DEPOSITS AT HALSTEAD, DUNMOW, THAXTEAD, &c.
ELEPHANT, HIPPOPOTAMUS, &c. IN ALLUVIAL DEPOSITS AT COPFORD & IN STOUR & COLNE VALLEYS
HARWICH
SEPTARIA
RED CRAG
The Naze
Walton on Naze
MAMMALIA, PLANTS & SHELLS IN ALLUVIUM
EXTENSIVE TRACTS OF BRICKEARTH AND GRAVEL BORDERING THAMES AND COAST
ENGLISH MILES
2 4 6 8 10
Index to New Series, 1" Ordnance
205 206 207
222 223 224
240 241 242
257 258 259
271 272 273
Lavenham
SUDBURY
IPSWICH
COLCHESTER
Halstead
Coggeshall
Kelvedon
Blackwater R.
Crouch R.
Wallasea I.
Foulness I.
Southminster
Shoebury Ness
Southend
Clacton on Sea
Colne Pt
R. Stour
Brightlingsea
Mersea
Tollesbury
Rochford


GLOUCESTERSHIRE
AND
NORTH WILTSHIRE.
THE TYPICAL FOSSILS OF THE LIAS OCCUR IN THE VALES OF GLOUCESTER AND EVESHAM, ALSO OF THE OOLITIC BEDS IN THE COTTESWOLDS.
NUMEROUS CORALS IN THE LOWER LIAS OF GLOUCESTERSHIRE & WARWICKSHIRE.
Index to New Series, 1" Ordnance
Stratford on Avon
Cheltenham
Cirencester
Malmesbury
Marlboro'
Devizes
Bath
WORCESTER SH.
WARWICK SH.
HEREFORD SH.
OXFORD S
Stratford on Avon
Shipston on Stour
Sutton under Braites
Pershore
Evesham
R. Avon
Upton on Severn
Ledbury
Tewkesbury
Forthampton
Newent
Ross
Mitcheldean
Lydbrook
Cheltenham
Gloucester
Winchcombe
Chipping Campden
Stow on the Wold
Northleach
Burford
Cowley
Brimpsfield
Bisley
Edgeworth
Severn

NORTH WILTSHIRE
CORAL BEDS IN INFERIOR OOLITE NEAR STROUD.
MANY FOSSILS IN RHÆTIC BEDS NEAR WESTBURY ON SEVERN
Index to Old Series, 1" Ordnance
ENGLISH MILES
CORALS AND CRINOIDEA
OOLITIC IRONSTONE AT WESTBURY
SAURIANS AT SWINDON
"GREYWETHER" SANDSTONES ON THE CHALK.
AMMONITES & CORALS IN CHALK NEAR DEVIZES.
BERKS H.
SOMERSET SH.
GLOUCESTER
STH WILTS
MALMSBURY
CRICKLADE
Swindon
WOOTTON BASSET
CHIPPENHAM
CALNE
MARLBOROUGH
DEVIZES
BATH
Bristol
Clifton
Keynsham
Saltford
Bradford
Trowbridge
Melksham
Corsham
Tetbury
Westbury
Pewsey
Savernake Sta.
Tottenham Park
Thornbury
Chepstow
Portskewett
Avonmouth
Henbury
Chipping Sodbury
Castle Combe
Littleton Drew
Badminton Park

HAMPSHIRE.
ENGLISH MILES
2 4 6 8 10 12 14
FLINT IMPLEMENTS IN DRIFT AT ST MARY BOURNE
Ludgershall
Tangley
Appleshaw
Linkenholt
Vernhams Dean
Netherton
Hurstbourne Tarrant
Penton Mewsey
Enham Knights
Kimpton
Fyfield
Weyhill
Thruxton
ANDOVER
Amport
Monkston
Up Clatford
Goodworth
Quarley
Grately
U. Wallop
Longstock
Leckford
Stockbridge
Crawley
Broughton
Kings Somborne
SALISBURY
81
WINCHE
Mottisfont
Mitchel marsh
E. Dean
Lockerley
Timsbury
Downton
Romsey
E. Wellow
Whichbury
Rockbourne
Breamore
Bramshaw
Cranbourne
Fritham
Fordingbridge
Stony Cross
Redbridge
Minstead
Harbridge
Ibsley
Ellingham
NEW FOREST
Eling
Dibden
Lyndhurst
Hythe
Beaulieu Rd.
Ring wood
92
Burley
Brockenhurst
Wimborn Minster
Christchurch Rd.
Bransgrove
Sway
Boldre
Sopley
Holdenhurst
100
Milton
LYMINGTON
93
CHRIST CHURCH
Hordle
Milford
Tuckton
Barton
EOCENE FOSSILS ABUNDANT.
Hengistbury Head
Hurst Cas.
FOSSIL FISH, TURTLE &c.
Yarmouth
Newtown
Wareham
Poole
DUNES
Bournemouth
PALMS, &c. FROM LEAF BEDS.
Studland Bay
Freshwater
FRESHWATER TESTACEA STRATA VERTICAL
Needles
IGUANODON
WEALDEN REPTILIAN REMAINS
FOSSILS
THE SO
WILTSHIRE
DORSET


Blackwater
Silchester
Stratfield Saye
Kingsclere
Tadley
Eversley
Yateley
Hartley Westpole
Mattingley
Farnborough
W. Heath
Sherborne St. John
Rotherwick
Newnham
Winchfield
St. Lawrence
Worting
Basingstoke
Mapledurwell
Dogmersfield
Church Oakley
Cliddesden
Winslade
Tunworth
Odiham
Crondall
Guildford
Farnham
N. Waltham
S. Warnborough
Nutley
Ellisfield
Herriard
Bentley
SURREY
COPROLITE BEDS
Popham
Woodmancot
E. Stratton
Lasham
Holybourne
Binstead
Bradley
Preston Candover
Shalden
Alton
Worldham
Bentworth
Northington
Wield
Swarraton
Kingsley
Woolmer Forest
Headley
Hartley Mauditt
Faringdon
Brighton
Martyr Worthy
Itchen Stoke
New Alresford
Ropley
Newton Valence
Selborne
Bramshot
Haslemere
Tisted
Empshot
Bishops Sutton
W. Tisted
Colemore
Tichborne
Cheriton
Bramdean
Priors Dean
Hawkley
Greatham
Kilmeston
Privet
Froxfield
W. Meon
Exton
Petworth
PETERSFIELD
Upham
E. Meon
Midhurst
Meon Stoke
S. Ambersham
Bishops Waltham
Buriton
Durley
Clanfield
Soberton
Charlton
Catherington
SUSSEX
Hambledon
Blendworth
Wickham
Arundel
Titchfield
Widley
Leigh
Fareham
Havant
Emsworth
Portchester
Warblington
CHICHESTER
Portsmouth Harb.
N. Hayling
Chichester Harbour
W. Thorney
Lee
Gosport
Alverstoke
Stokes Bay
Southsea
Hayling I.
PORTSMOUTH
Bognor
E. Cowes
Osborne
Whippingham
SPITHEAD
Ryde
Binstead
St. Helens
Bembridge
Foreland
Brading
Yaverland
Culver Cliffs
Sandown
Godshill
Shanklin
Dunnose Hd.
Ventnor
St. Lawrence
Undercliff
Whitwell
MUCH DRIFT
GRAVEL AND
LOAM OVER
TERTIARY
AREAS : HAVANT
TO BOURNEMOUTH, ETC.
IGUANODON REMAINS.
Index to New Series, 1" Ordnance
267 268 269
282 283 284 285
Andover Basingstoke
298 299 300 301
Winchester
314 315 316 317
Southampton
329 330 331 332
Bournemouth Portsmouth
343 344 345
Isle of Wight


SHROPSH.
WORCESTERSH.
RADNORSH.
HEREFORD
CRUSTACEA IN LOWER LUDLOW BEDS
CORALS IN WENLOCK LIMESTONE NEAR AYMESTRY
AYMESTRY LIMESTONE RICH IN SHELLS, &c.
REMAINS OF FISHES, CRUSTACEA &c.
REMAINS OF FISHES IN QUARRIES IN LOWER "OLD RED" NEAR LEOMINSTER.
REMAINS OF CRUSTACEA & FISHES, - PTERASPIS, CEPHALASPIS, HOLOPTYCHIUS, IN LOWER OLD RED SANDSTONE AT PONTRILAS, LEDBURY &c.
Index to Old Series, 1" Ordnance
56 55
42 43
36 35
LUDLOW 42
130 Tenbury
131 LEOMINSTER
147 WEOBLEY
Hay 156
Kington
Ledbury
Leintwardine
Downton
Burrington
Aston
Brampton Bryan
Leinthall
Wigmore
Lingen
Kinsham
Aymestry
Bolstone
Croft
Orleton
Yarpole
Lucton
Eye
Eyeton
Shobdon
Byton
Presteign
Knill
Titley
Staunton
Kingsland
Eardisland
Pembridge
Lionshall
Dilwyn
Stretford
Birley
Brimfield
Middleton
Leysters
Kimbolton
Puddlestone
Hatfield
Docklow
Bredenbury
Marston
Pencomb
Stoke Prior
Whitborne
Edwin Loach
Thornbury
Wolferlow
Bromyard
Burleigh
Stanford Bishop
Bodenham
Wistaston
Moreton Jeffries
Bishops Frome
Evesbach
Castle Frome
Felton
Much Cowarne
Pitschard
Preston Wynne
Sutton
St. Michael
St. Nicholas
Amberley
Dinmore
Canon Pyon
Kings
Wormesley
Sarnesfield
Kinnersley
Brilley
Willersley
Norton Canon
Staunton on Wye
Winforton
Letton
Bredwardine
Brobury
Mansell Gamage
Monnington
Burghill
Credenhill
Stretton
Holmer
Huntington
Pipe
Withington
West Hide
Lugwardine
Ashperton
Stretton Grandsome
Bosbury
Coddington
Colwall
Tarrington
Pixley
Dormington
Stoke Edith
Weston Bishop
Putley
Woolhope
Fawnhope
Hope
Breinton
Clehonger
Eaton Bishop
Madley
Tiberton
Preston
Moccas
Dorstone
Cusop
Clifford
Graswall Chap.
Turnaston
Michael Church
Kingston
Thruxton
Allensmore
Bullingham
Dinedor
Dewshall
Bolston
Ballingham
How Caple
Kilpeck
Much Birch
Devereux
Abbey Dore
Bacton
St. Margarets
Donnington
Eastnor
Much Marcle
Yatton Chap.

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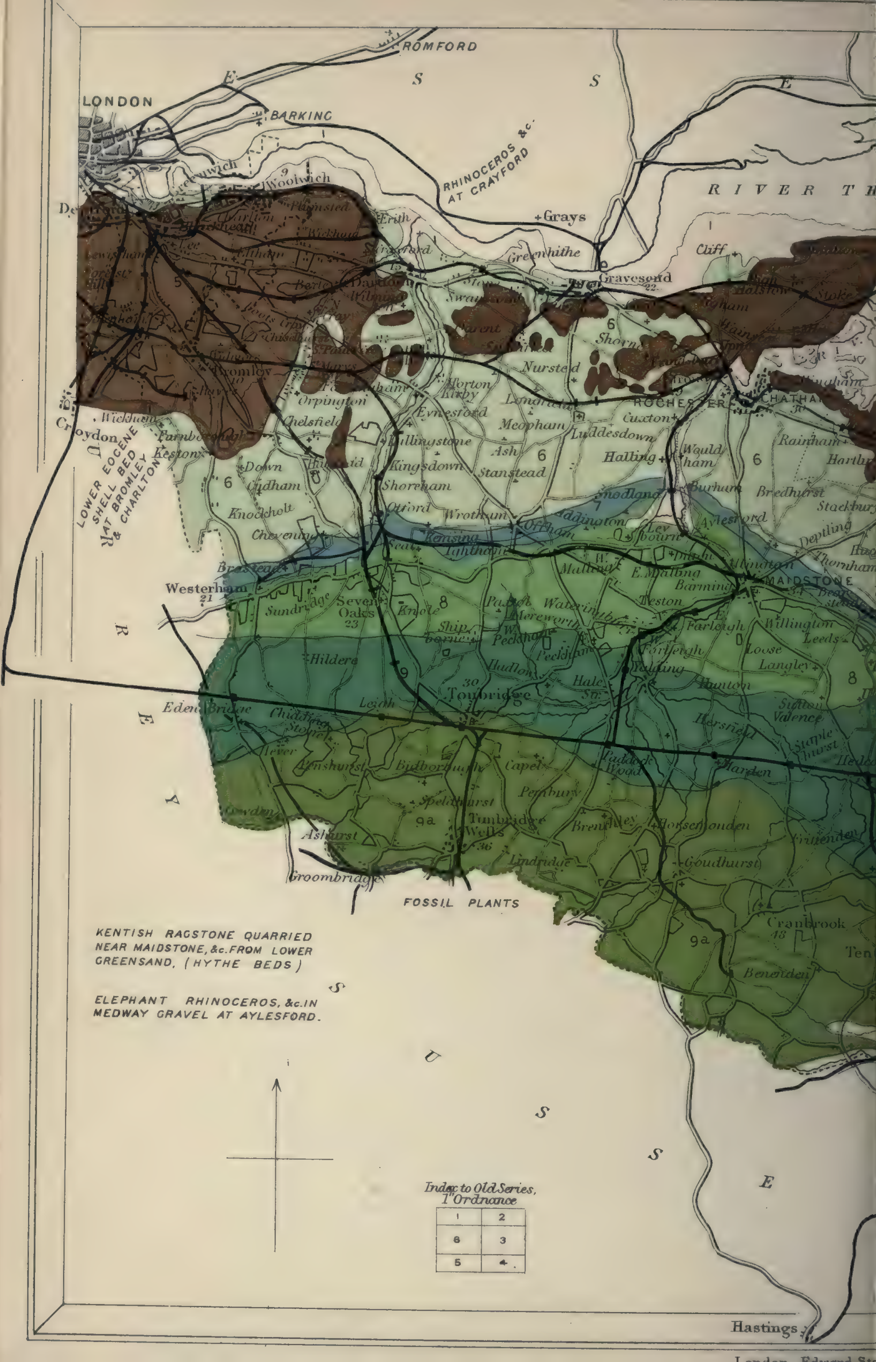
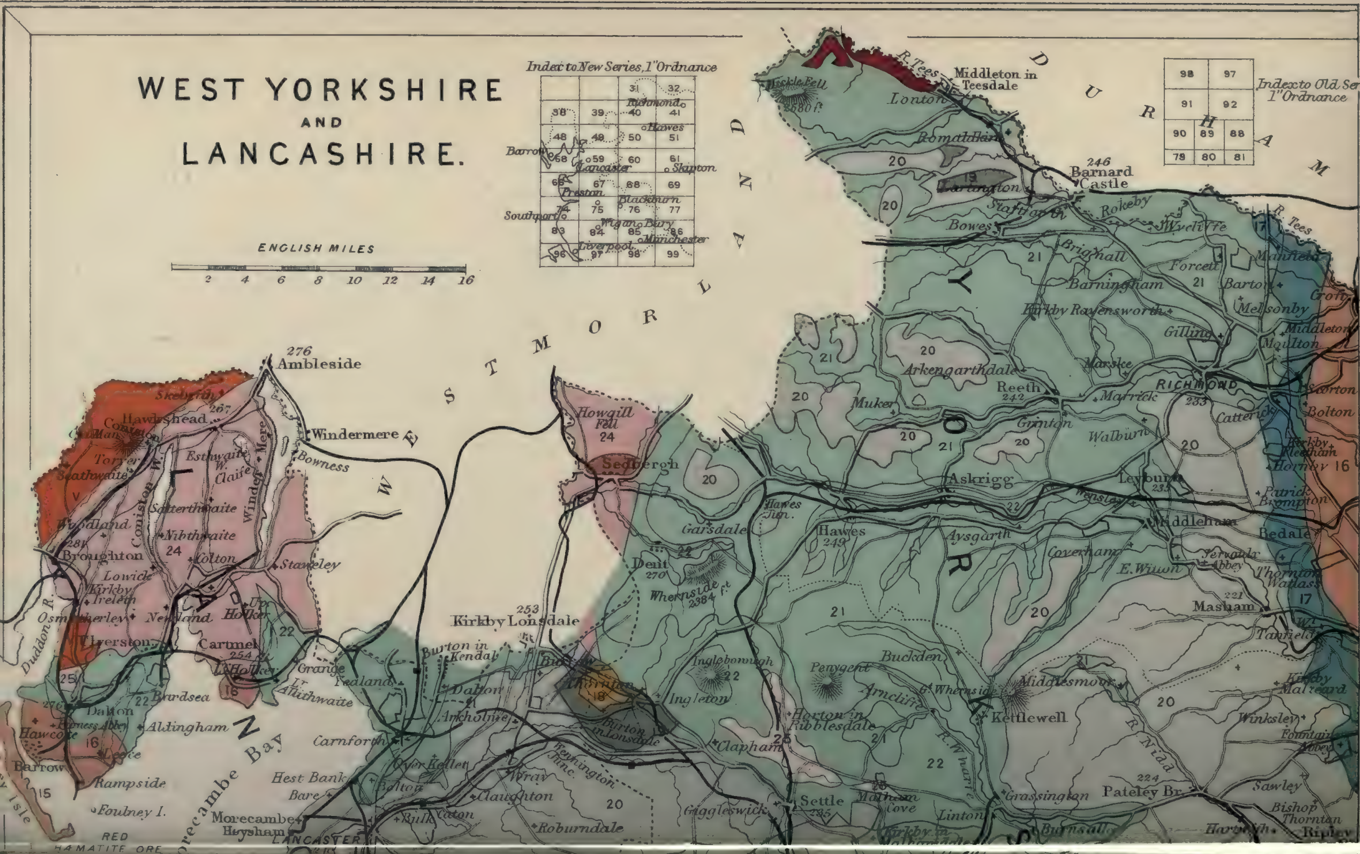

ROMFORD
LONDON
BARKING
RHINOCEROS &c. AT CRAYFORD
RIVER TH
Woolwich
Greenwich
Erith
Grays
Greenhithe
Gravesend
Cliff
Shorne
Nurstead
ROCHESTER
CHATHAM
Cuxton
Meopham
Luddesdown
Halling
Wouldham
Rainham
Burham
Bredhurst
Stockbury
Aylesford
Detling
Thornham
MAIDSTONE
Orpington
Chelsfield
Eynesford
Kingsdown
Shoreham
Otford
Wrotham
Snodland
Addington
Offham
Ightham
Kemsing
Croydon
Keston
Down
Cudham
Knockholt
Chevening
Brasted
Westerham
Sundridge
Seven Oaks
Knole
Mereworth
E. Malling
Barming
Teston
Farleigh
Loose
Langley
Linton
Sutton Valence
Staplehurst
Marden
Paddock Wood
Capel
Pembury
Brenchley
Horsmonden
Goudhurst
Cranbrook
Benenden
Tonbridge
Leigh
Hildenborough
Hadlow
Eden Bridge
Chiddingstone
Hever
Penshurst
Bidborough
Speldhurst
Tunbridge Wells
Lindridge
Ashurst
Groombridge
Hastings
LOWER EOCENE SHELL BED AT BROMLEY & CHARLTON
FOSSIL PLANTS
KENTISH RAGSTONE QUARRIED NEAR MAIDSTONE, &c. FROM LOWER GREENSAND, (HYTHE BEDS)
ELEPHANT RHINOCEROS, &c. IN MEDWAY GRAVEL AT AYLESFORD.
SURREY
SUSSEX
Index to Old Series, 1" Ordnance
1 2
6 3
5 4.

KENT.


ROCHFORD
GRAYS, ESSEX.-CORBICULA FLUMINALIS
HIPPOPOTAMUS MAJOR, RHINOCEROS
LEPTORHINUS, ELEPHAS ANTIQUUS.
Nore Light
ENGLISH MILES
2 4 6 8 10 12
Sheerness
PLANTS, FRUITS, REPTILIA, MOLLUSCA,
OF THE LONDON CLAY.
EXTINCT BIRDS, &c.
THANET SANDS, LOWEST BEDS
OF EOCENE SERIES.
AMMONITES
ELEPHAS
PRIMIGENIUS
Westgate
Margate
72
Foreness Pt.
NORTH
FORELAND
Broadstairs
Reculvers
Herne Bay
Whitstable
Birchington
St Nicholas
Acol
THANET
St Laurence
Ramsgate
73
Pegwell
Bay
Sandwich
Herne
Kingsdown
Doddington
Sheldwich
Throwley
Leveland
Stalisfield
Boughton
Stephen
Chartham
CANTERBURY
Horton
Neckington
Chilham
Bishopbourn
Petham
Up. Hardres
Godmersham
Waltham
Stelling
Barham
Bridge
Adisham
Goodnestone
Eastry
Betshanger
Barfrestone
Eythorne
Ham
Sholden
Deal
Sandown
Cast.
DEAL
74
Walmer
Ripple
Ringswold
Waldershare
Oxney
Whitfield
St Margarets
at Cliffe
SOUTH
FORELAND
West
Cliffe
Buckland
Denton
Wooton
Swingfield
Acryse
Lyminge
Hougham
DOVER
71
Shakespeare Cliff
COAL BORING
East Wear Bay
FOLKESTONE
70
Newington
Cheriton
Molash
Challock
Charing
Westwell
Hastingleigh
Elmsted
Brabourne
Stowting
Monks
Horton
Smeeth
Postlin
Sellinge
Aldington
Lympne
Orleston
Bilsington
Bethersden
Kingsnorth
Mersham
Hythe
65
Sandgate
Shorncliffe
CEPHALOPODA & CRUSTACEA
Burmarsh
New
Church
ROMNEY
Snave
Dymchurch
Fairfield
Brenzet
Hope
MARSH
Old Romney
New Romney
70
Lydd
Dunge
Marsh
ACCUMULATING SHINGLE
DUNGE NESS
Index to New Series, 1" Ordnance
Gravesend 270
271
272
273
Herne Bay 274
Ramsgate
Sevenoaks 287
Maidstone 288
289
Canterbury 290
Tenterden 303
304
305
Dover 306
Folkestone
321



WEST YORKSHIRE
AND
LANCASHIRE.
ENGLISH MILES
2 4 6 8 10 12 14 16
Index to New Series, 1" Ordnance
Index to Old Series 1" Ordnance
Richmond
Hawes
Skipton
Barrow
Lancaster
Preston
Blackburn
Southport
Wigan
Bury
Manchester
Liverpool
DURHAM
WESTMORLAND
YORK
LANC
Middleton in Teesdale
Barnard Castle
Richmond
Ambleside
Windermere
Bowness
Hawkshead
Coniston
Sedbergh
Howgill Fell
Kirkby Lonsdale
Burton in Kendal
Carnforth
Morecambe Bay
Morecambe
Heysham
Lancaster
Hest Bank
Bare
Settle
Giggleswick
Clapham
Ingleton
Horton in Ribblesdale
Kettlewell
Grassington
Pateley Br.
Masham
Leyburn
Middleham
Bedale
Askrigg
Hawes
Reeth
Muker
Aysgarth
Dent
Whernside 2384 ft
Ingleborough
Penygent
Cartmel
Ulverston
Dalton
Barrow
Rampside
Foulney I.
Broughton
RED HAMATITE ORE

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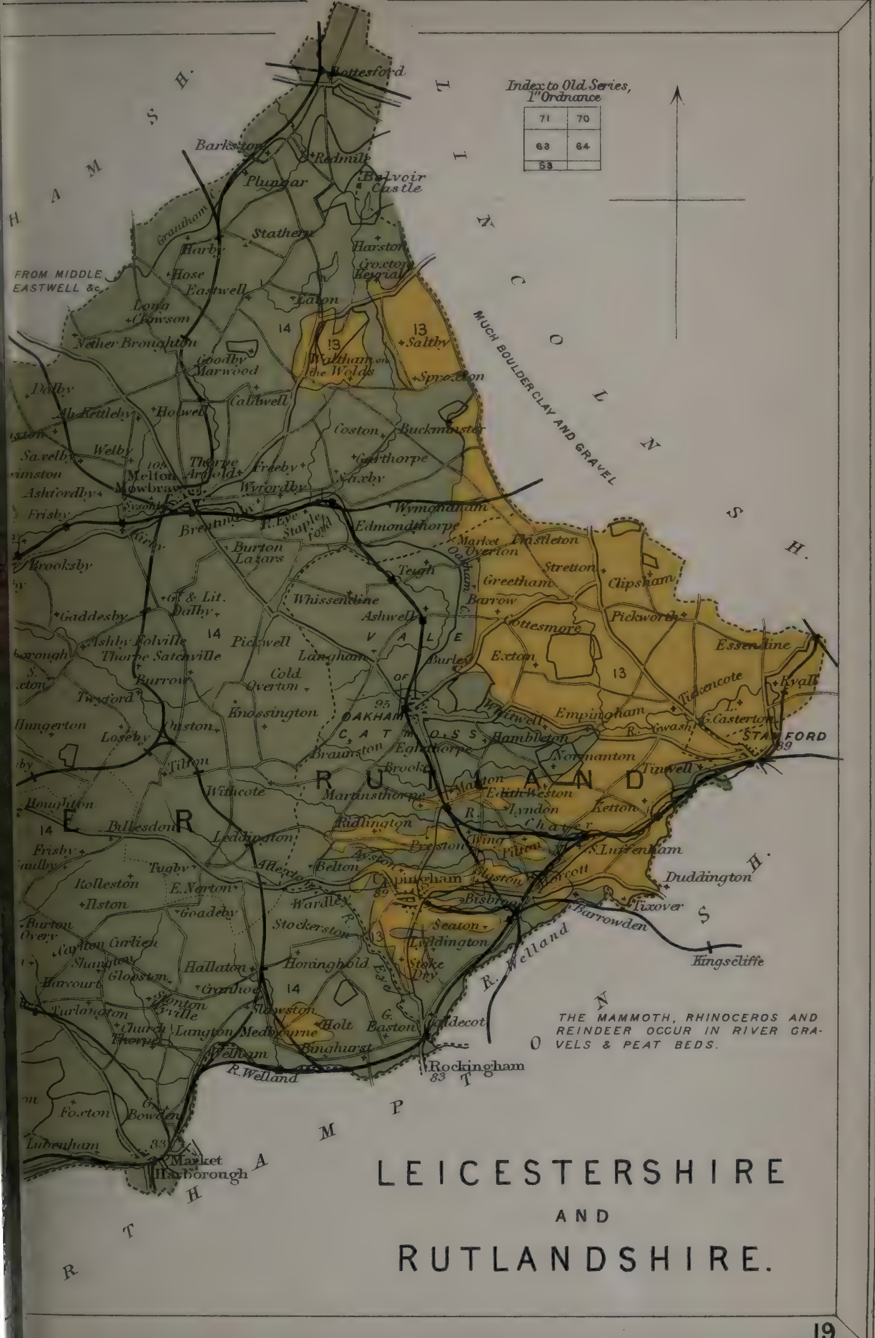
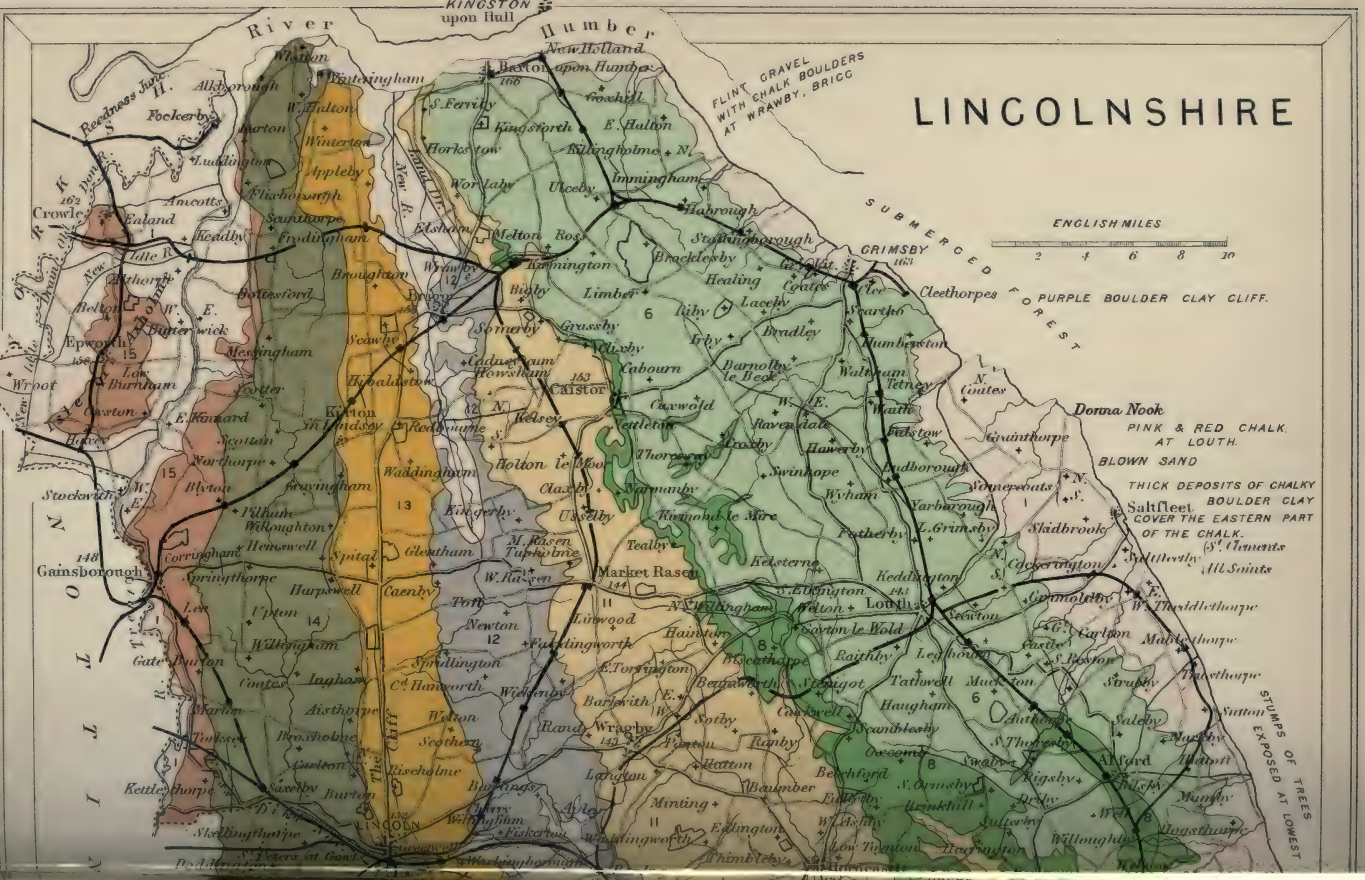
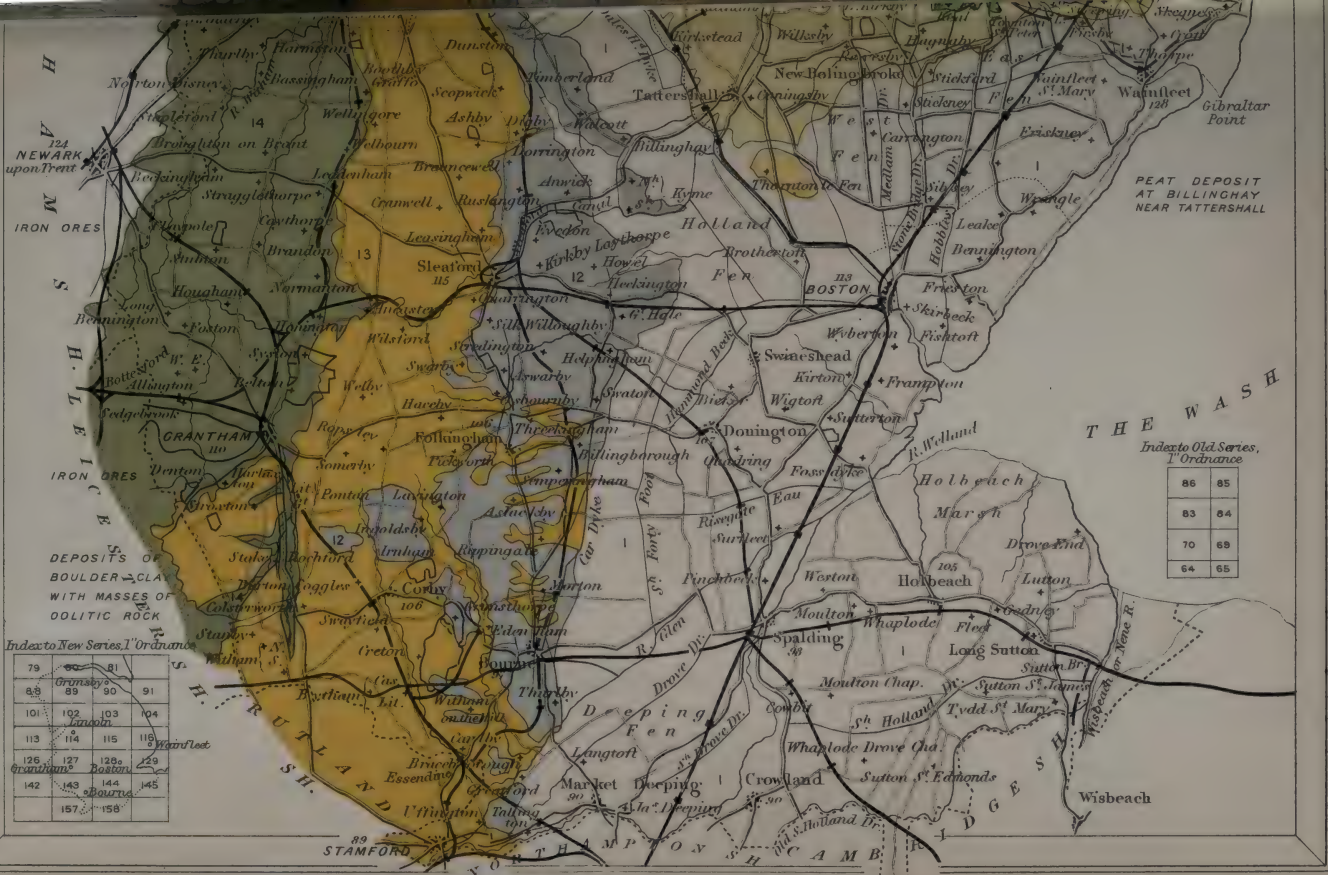
ENGLISH MILES
2 4 6 8 10
Index to New Series, 1" Ordnance
126
141 142 143
155 156 157
169 170 171
Ashby de la Zouch
Melton Mowbray
Oakham
Leicester
NOTTINGHAM
REPTILES, FISH, AND NU
AMMONITES OCCUR IN THE
LIAS AT BARROW ON SOAR
MAMMOTH, &c. IN DRIFT OF
SOAR VALLEY.
SLATE QUARRIES
AT SWITHLAND
GRANITE AND
SYENITE QUARRIES AT MOUNT SORREL,
CROBY & MARKFIELD. PRE-
-CAMBRIAN SLATES IN CHARNWOOD
FOREST. AN ANTICLINAL AXIS TRAVERSES
CHARNWOOD FOREST FROM N.W. TO S.E.
D E R B Y S H.
N O T T I
W A R W I C K S H.
L E I C E S
COALFIELD
CHARNWOOD FOREST
R. Trent
Trent Sta.
Hemington
Lockington
Castle Donington
Kegworth
Isley Walton
Diseworth
Tonge
Long Whatton
Breedon
Belton
Hathern
Stanford
Hoton
Staunton Harrold
Worthington
Osgarthorpe
Dishley Grange
Burton
Sheepshead
Loughborough
Boothorpe
Ashby de la Zouch
Blackfordby
Grace Dieu
Quorndon
Barrow
Moira
Packington
Swannington
Woodhouse
Mount Sorrel
Sileby
Nether Seal
Ravenstone
Coalville
Normanton
Measham
Snibston
Hugglescote
Swithland
Rothley
Heather
Sweepston
Newtown Linford
Thurmaston
Wanlip
Appleby Magna Parva
Ibstock
Markfield
Anstey
Birstall
Norton
Thornton
Groby
Belgrave
Nailstone
Shackerstone
Ratby
Glenfield
Twycross
Congerston
Carlton
Newbold Vernon
Kirby Muxloe
LEICESTER
Orton
Desford
Market Bosworth
Braunstone
Sibson
Cadeby
Peckleton
Aylestone
Sheepy
Sutton Cheney
Shenton
Kirkby Mallory
Lubbesthorpe
Enderby
Ratcliffe & Culey
Stapleton
Thurlaston
Witherley
Dadlington
Earl Shilton
Narborough
Atherstone
Fenny Drayton
Stoke Golding
Barwell
Elmesthorpe
Whetstone
Blaby
Croft
Countesthorpe
Higham
Hinckley
Cosby
Stoney Stanton
Foston
Willoughby Waterless
Sapcote
Aston Flamville
Burbage
Sharnford
Broughton Astley
Arnesby
Nuneaton
Wigston Parva
Ashby Magna
Shearsby
Dunton Basset
Leire
Lit. Peatling
Ashby Parva
Gilmorton
Upr. Claybrook
Kimcote
Ullesthorpe
Bitteswell
Lutterworth
Misterton
Cotesbach
S. Kilworth
Shawell
Swinford
Catthorpe



LEICESTERSHIRE AND RUTLANDSHIRE.


LINCOLNSHIRE
ENGLISH MILES
2 4 6 8 10
FLINT GRAVEL WITH CHALK BOULDERS AT WRAWBY, BRIGG
SUBMERGED FOREST
PURPLE BOULDER CLAY CLIFF.
PINK & RED CHALK AT LOUTH.
BLOWN SAND
THICK DEPOSITS OF CHALKY BOULDER CLAY COVER THE EASTERN PART OF THE CHALK.
STUMPS OF TREES EXPOSED AT LOWEST
KINGSTON upon Hull
River Humber
New Holland
Barton upon Humber
GRIMSBY
Cleethorpes
Donna Nook
Saltfleet
Louth
Market Rasen
Caistor
Gainsborough
Crowle
Epworth
LINCOLN
Alford
Wragby



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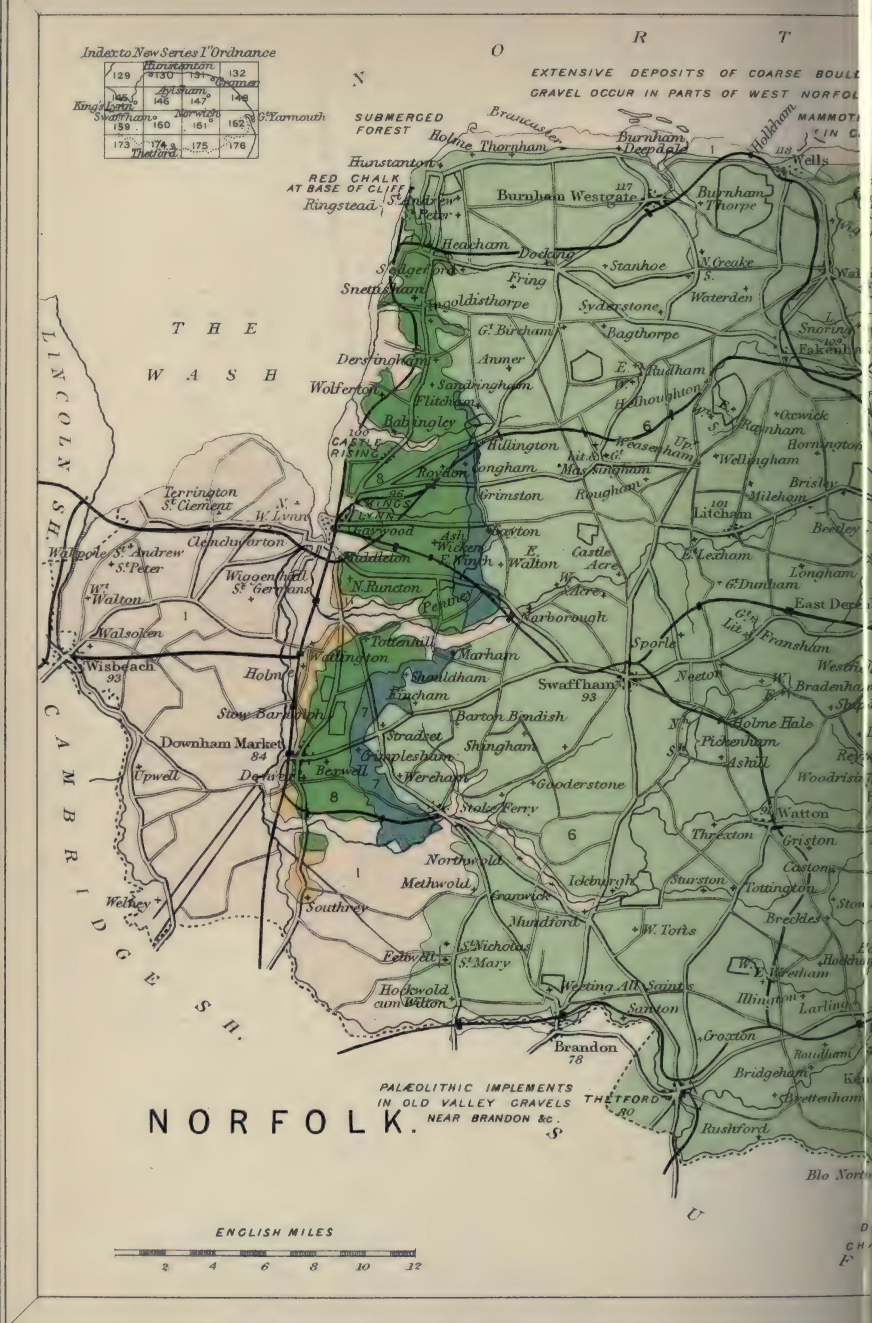

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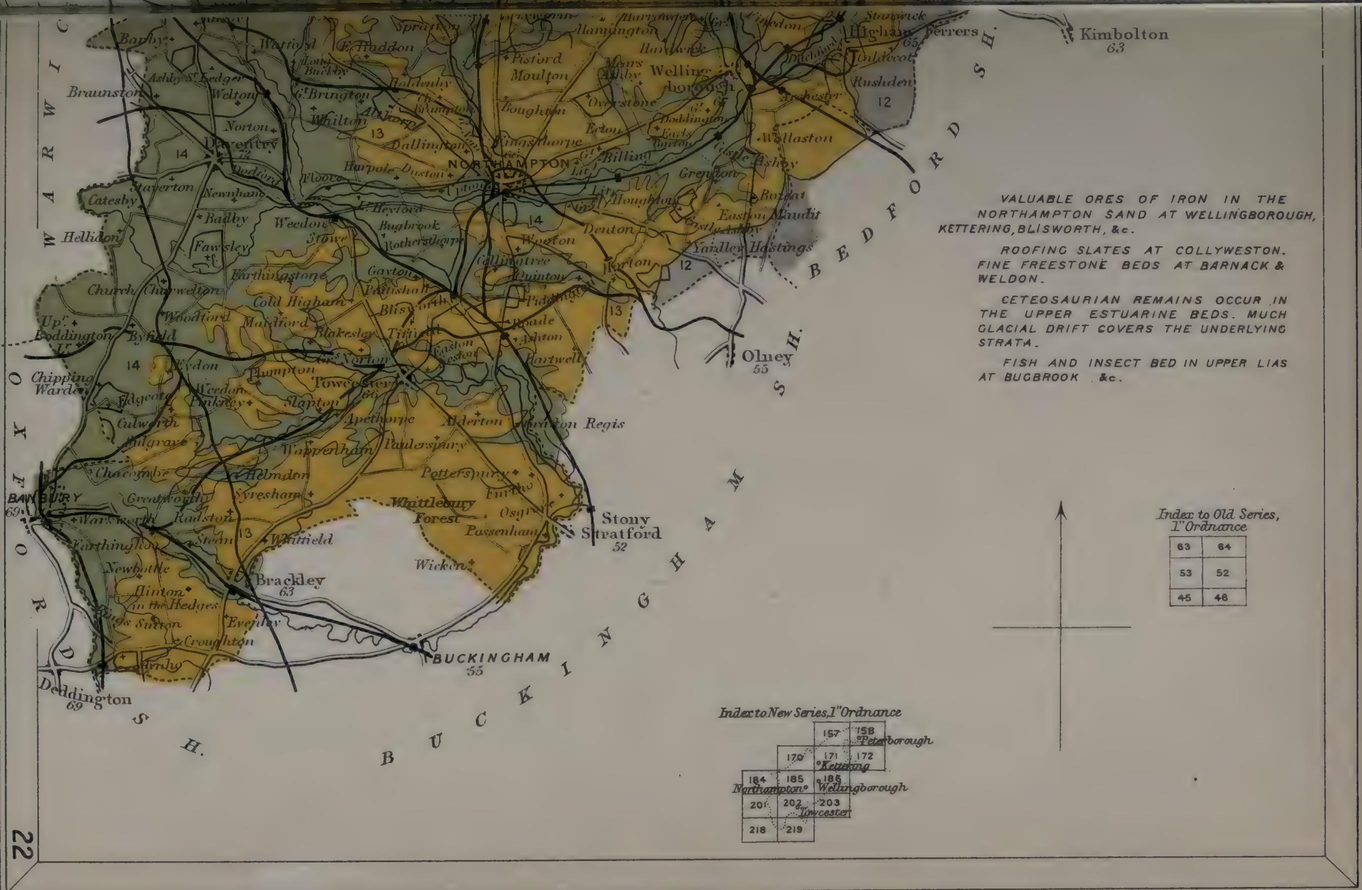
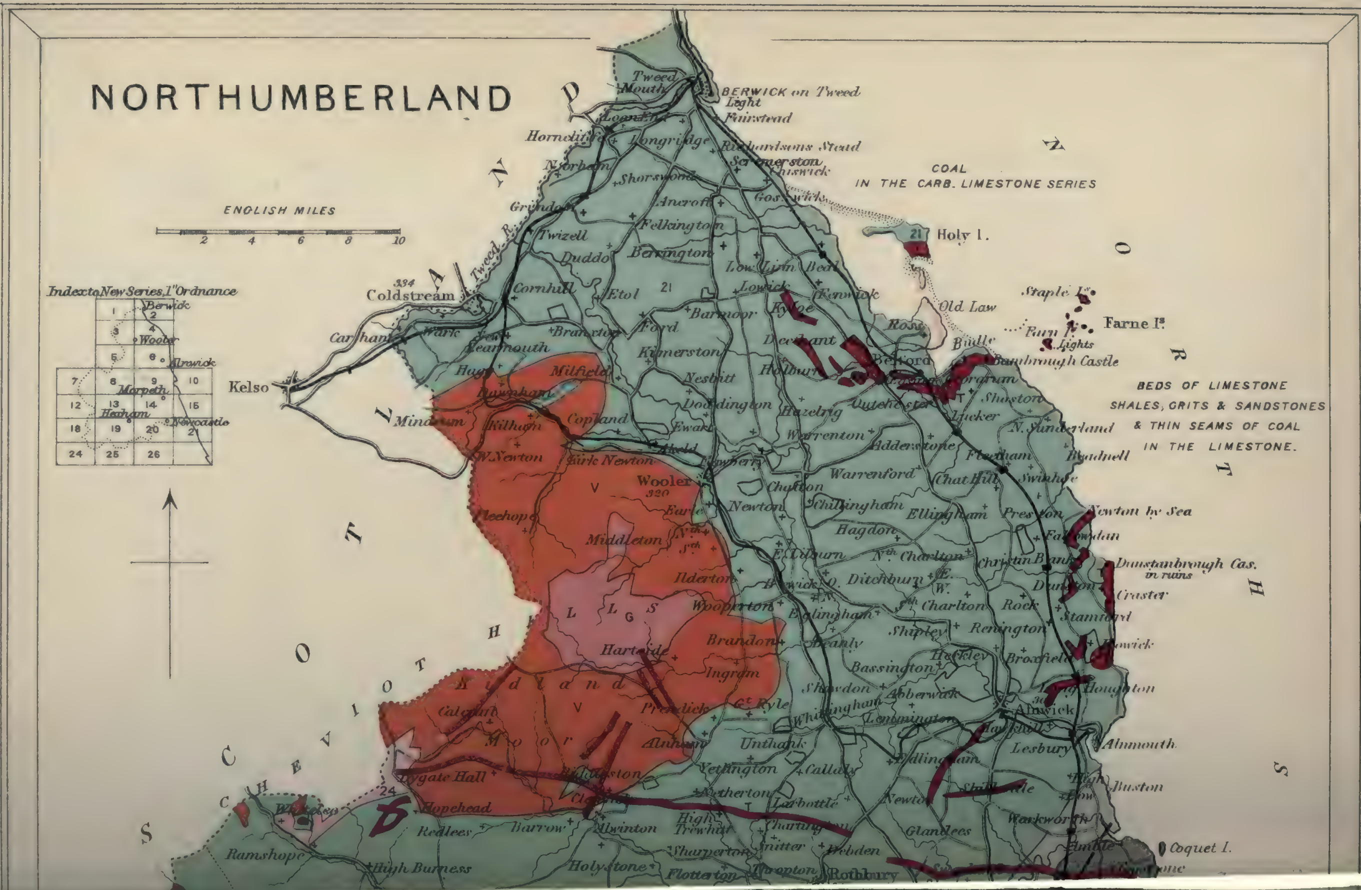
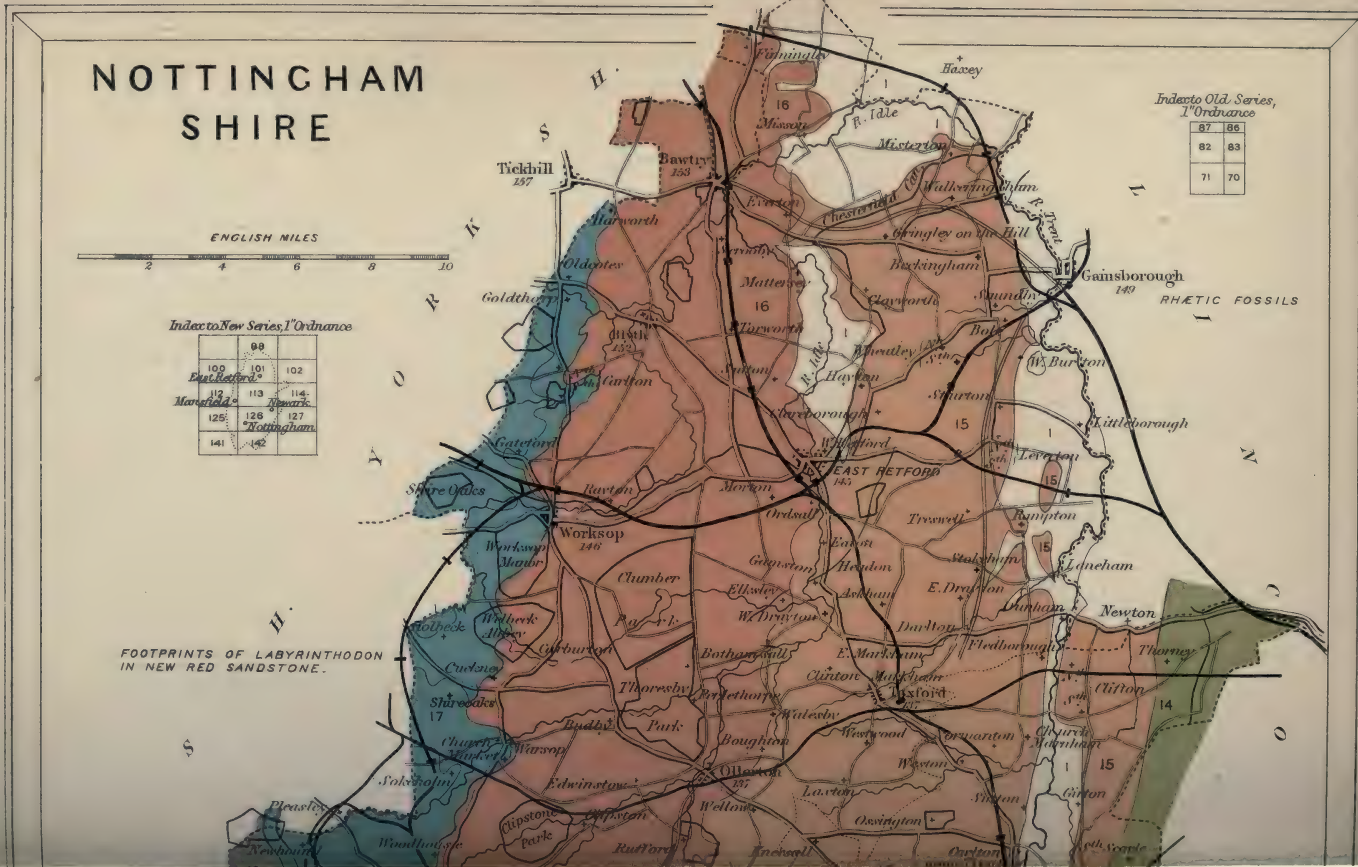
NORTHAMPTONSHIRE.

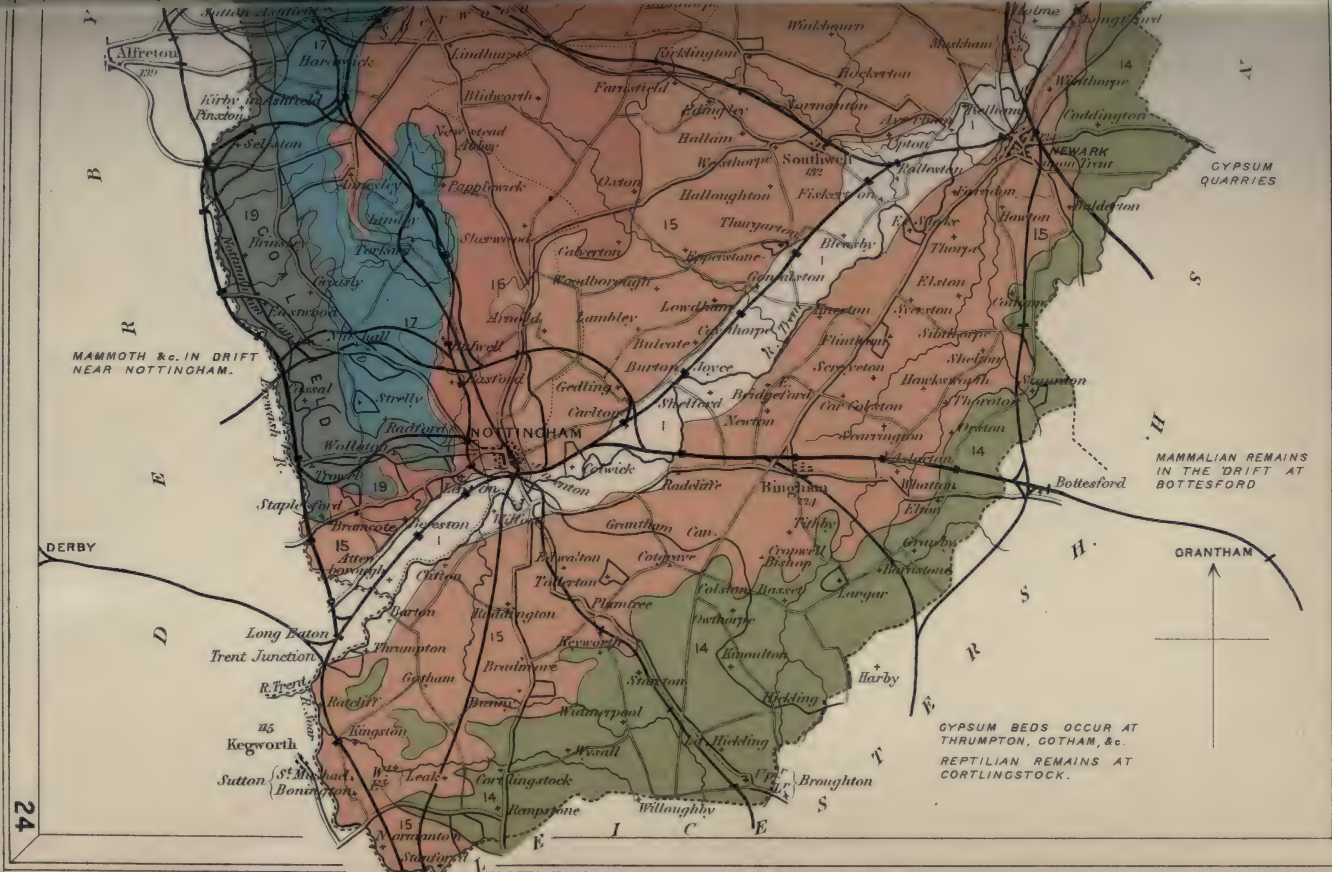

VALUABLE ORES OF IRON IN THE NORTHAMPTON SAND AT WELLINGBOROUGH, KETTERING, BLISWORTH, &c.
ROOFING SLATES AT COLLYWESTON. FINE FREESTONE BEDS AT BARNACK & WELDON.
CETEOSAURIAN REMAINS OCCUR IN THE UPPER ESTUARINE BEDS. MUCH GLACIAL DRIFT COVERS THE UNDERLYING STRATA.
FISH AND INSECT BED IN UPPER LIAS AT BUGBROOK &c.
Index to Old Series, 1" Ordnance
63 64
53 52
45 46
Index to New Series, 1" Ordnance
157 158 Peterborough
170 171 172 Kettering
184 185 186
Northampton Wellingborough
201 202 203 Towcester
218 219
BEDFORD SH.
BUCKINGHAM SH.
WARWIC
OXFORD
NORTHAMPTON
Kimbolton 63
Olney 55
Stony Stratford 52
BUCKINGHAM 55
Brackley 63
Deddington 69
BANBURY 69
Daventry 72
Towcester 66
Wellingborough 65
Higham Ferrers 65
Whittlebury Forest
22



NORTHUMBERLAND
ENGLISH MILES
2 4 6 8 10
Index to New Series 1" Ordnance
COAL
IN THE CARB. LIMESTONE SERIES
BEDS OF LIMESTONE
SHALES, GRITS & SANDSTONES
& THIN SEAMS OF COAL
IN THE LIMESTONE.
BERWICK on Tweed
Holy I.
Farne Is.
Coquet I.
Bambrough Castle
Dunstanbrough Cas. in ruins
Coldstream
Kelso
Wooler
Alnwick
Alnmouth
Rothbury
Newton by Sea

CARBONIFEROUS FOSSILS ALONG COAST
GLACIAL DRIFT AND BOULDER CLAY COVER LARGE PORTIONS OF NORTHUMBERLAND & DURHAM
NORTHUMBERLAND
COAL FIELD
CUMBERLAND
DURHAM
NEWCASTLE
Gateshead
MORPETH
NTH SHIELDS
Long
Cullercoats
Tynemouth
Howden Pans
R. Tyne
Blaydon
Elswick
Newburn
Wylam
Prudhoe
Corbridge
Hexham
Dilston
Haltwhistle
Bellingham
Alston
Allendale
Whitfield
Morley Hill
Knaresdale
Kirkhaugh
Whitley Com.
Lambley
Blanchland
Newbiggin
Birkenside
Shotley
Whittonstall
R. Derwent
Roman Wall
Irthing R.
Whiteside
Greenhead
Blenkinsop
Kielder
Hunters Burn
Plashetts
Wellhaugh
Nth Tyne
Falstone
Smales
Wrackhope
Greystead
Chirdon
Clintburn
Coal Coats
Gt Longbrough
Chipchase
Wark
Birtley
Ellingham
Charlton
Broomhope
W. Woodburn
Otterburn
Elsdon
Fallowlees
Harwood
Rothley
Long Witton
Nunnykirk
Stanton
Pigdon
Thornton
Mitford
Edington
Whalton
Meldon
Belsay
Bingfield
Matfen
Ryall
Halton
Whittington
Cheesburn
Colleston
Heddon
Walbottle
Kenton
Benton
Wallsend
Killingworth
Earsdon
Seghill
Cramlington
Whitridge
Blyth
R. Blyth
Bedlington
Cowpen
Horton
Hartford
R. Wansbeck
Newbiggin
Hurst
Longhirst
Ulgham
Ellington
Cresswell
Druridge
Druridge B.
Widdrington
Tritlington
Earsdon
Longhorsley
Wingates
Simonside
Ewesley
Corsenside
Monkridge
Burnt Grains
Ruken
Horsley
Moors
Riggend
Thorneyburn
Newbrough
Brokenhaugh
Thorngrafton
Wall Town
Haydon Br.
Warden
St Johnlee
Aydon
Anick
Fallowfield
Welton
Nafferton
Ovingham
Horsley
Bywell
Stocksfield
Bromley
High Fotherly
Styford
Dotland
Catton
Whitley Chop
Staward
Stobbilee
Riddlehampe
Lesterhall
Turneyshield
Eshies
Merryknow
Eals
Lintley
Threepwood
Ramshaw
St Oswalds
Humshaugh
Chollerton
Swinburne
Kirkheaton
Capheaton
Bradford
Ogle
Stannington
Blagdon
Kirkley
Higham Dykes
Ponteland
Prestwick
Walsington
Dearham
Hawick
Kirkharle
Whelpington
Wallington
Hartburn
Bolam
Netherton
E. Duddo
Hebburn
Pegswood
Fenrother
Hepscot
Bothal
Cambois
Murton
Preston


NOTTINGHAM SHIRE
ENGLISH MILES
2 4 6 8 10
Index to New Series, 1" Ordnance
98
100 101 102
East Retford
112 113 114
Mansfield Newark
125 126 127
Nottingham
141 142
Index to Old Series, 1" Ordnance
87 86
82 83
71 70
RHÆTIC FOSSILS
FOOTPRINTS OF LABYRINTHODON
IN NEW RED SANDSTONE.
YORKSH.
LINCOLNSHIRE
Tickhill
157
Bawtry
153
Finningley
Haxey
Misson
R. Idle
Misterton
Everton
Walkeringham
R. Trent
Gringley on the Hill
Gainsborough
149
Harworth
Oldcotes
Scrooby
Beckingham
Mattersey
Clayworth
Saundby
Goldthorp
Blyth
152
Torworth
Bole
Wheatley
W. Burton
Carlton
Sutton
Hayton
Sturton
Littleborough
Clareborough
Leverton
Gateford
EAST RETFORD
145
Shire Oaks
Worksop
146
Rayton
Morton
Ordsall
Treswell
Rampton
Worksop Manor
Clumber
Gamston
Eaton
Headon
Stokeham
Laneham
Ellesley
Askham
E. Drayton
Dunham
Newton
W. Drayton
Welbeck Abbey
Holbeck
Carburton
Darlton
Fledborough
Thorney
Cuckney
Bothamsall
E. Markham
Thoresby
Clinton
Markham
Tuxford
137
Clifton
Perlethorpe
Shireoaks
Walesby
Budby
Park
Boughton
Westwood
Ormanton
Church Warsop
Warsop
Weston
Ollerton
137
Sookholm
Edwinstow
Laxton
Girton
Pleasley
Clipstone Park
Clipston
Wellow
Ossington
Newhouse
Woodhouse
Rufford
Kneesall
Carlton
16
1
15
14
17



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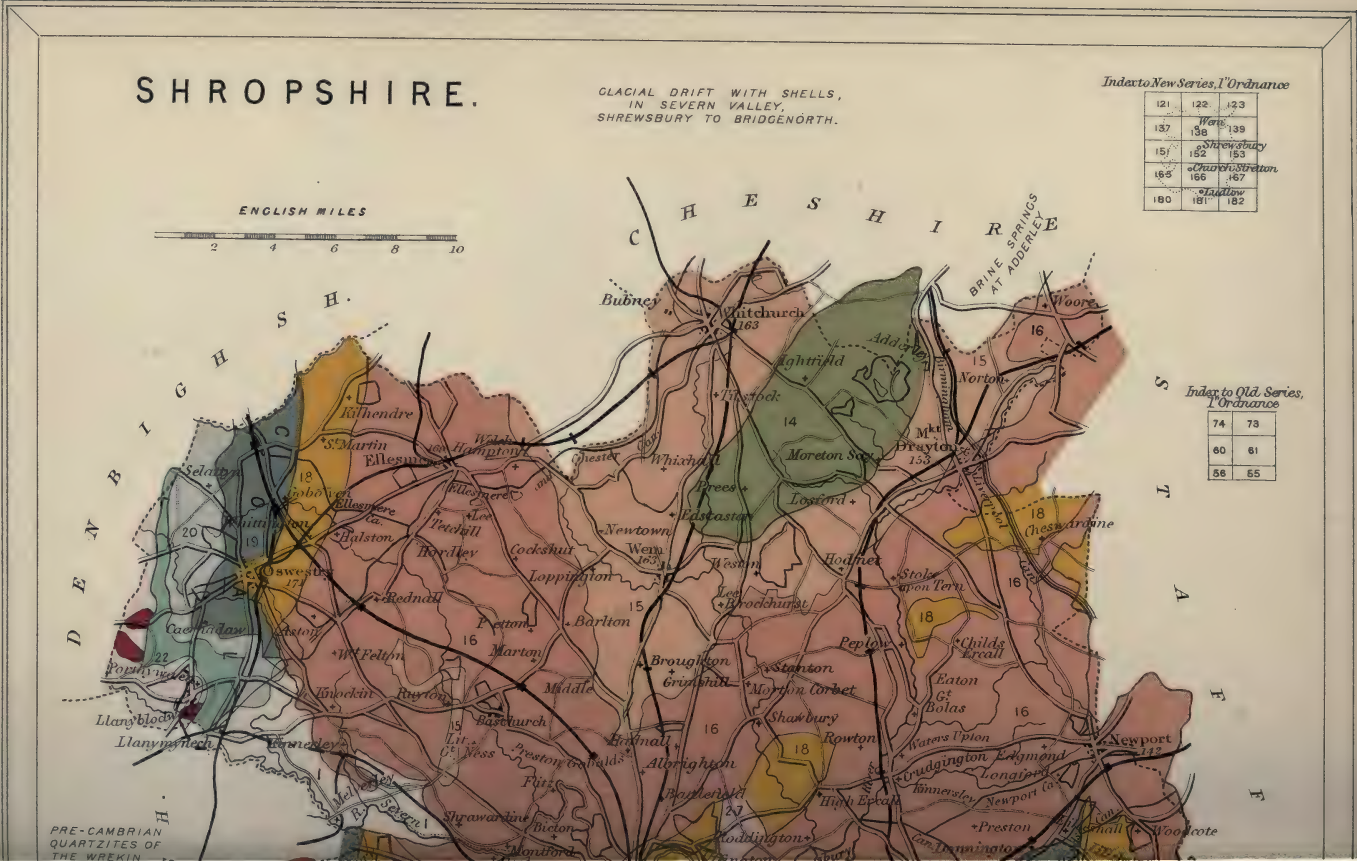
SHROPSHIRE.
GLACIAL DRIFT WITH SHELLS, IN SEVERN VALLEY, SHREWSBURY TO BRIDGENORTH.
Index to New Series, 1" Ordnance
121 122 123
137 138 139
151 152 153
165 166 167
180 181 182
Wem
Shrewsbury
Church Stretton
Ludlow
Index to Old Series, 1" Ordnance
74 73
60 61
56 55
ENGLISH MILES
2 4 6 8 10
CHESHIRE
STAFF
DENBIGHSH.
BRINE SPRINGS AT ADDERLEY
PRE-CAMBRIAN QUARTZITES OF THE WREKIN
Whitchurch
Bubney
Tilstock
Ightfield
Adderley
Woore
Norton
Mkt Drayton
Moreton Say
Whixhall
Prees
Lostford
Edstaston
Newtown
Wem
Weston
Lee Brockhurst
Hodnet
Stoke upon Tern
Cheswardine
Childs Ercall
Peplow
Eaton
Gt Bolas
Newport
Waters Upton
Crudgington
Edgmond
Longford
Kinnersley
Preston
Woodcote
High Ercall
Rowton
Shawbury
Stanton
Moreton Corbet
Broughton
Grinshill
Hadnall
Albrighton
Battlefield
Roddington
Preston Gobalds
Fitz
Bicton
Montford
Shrawardine
Melverley
R. Severn
Kinnerley
Llanymynech
Llanyblodwel
Porthywaen
Caerhadaw
Aston
Oswestry
Whittington
Gobowen
Selattyn
Kilhendre
St Martin
Ellesmere
Welsh Hampton
Ellesmere Ca.
Halston
Tetchill
Lee
Hordley
Cockshutt
Loppington
Rednall
Petton
Barlton
W Felton
Marton
Knockin
Ruyton
Baschurch
Middle
Lit. Ness
Gt Ness
Birmingham

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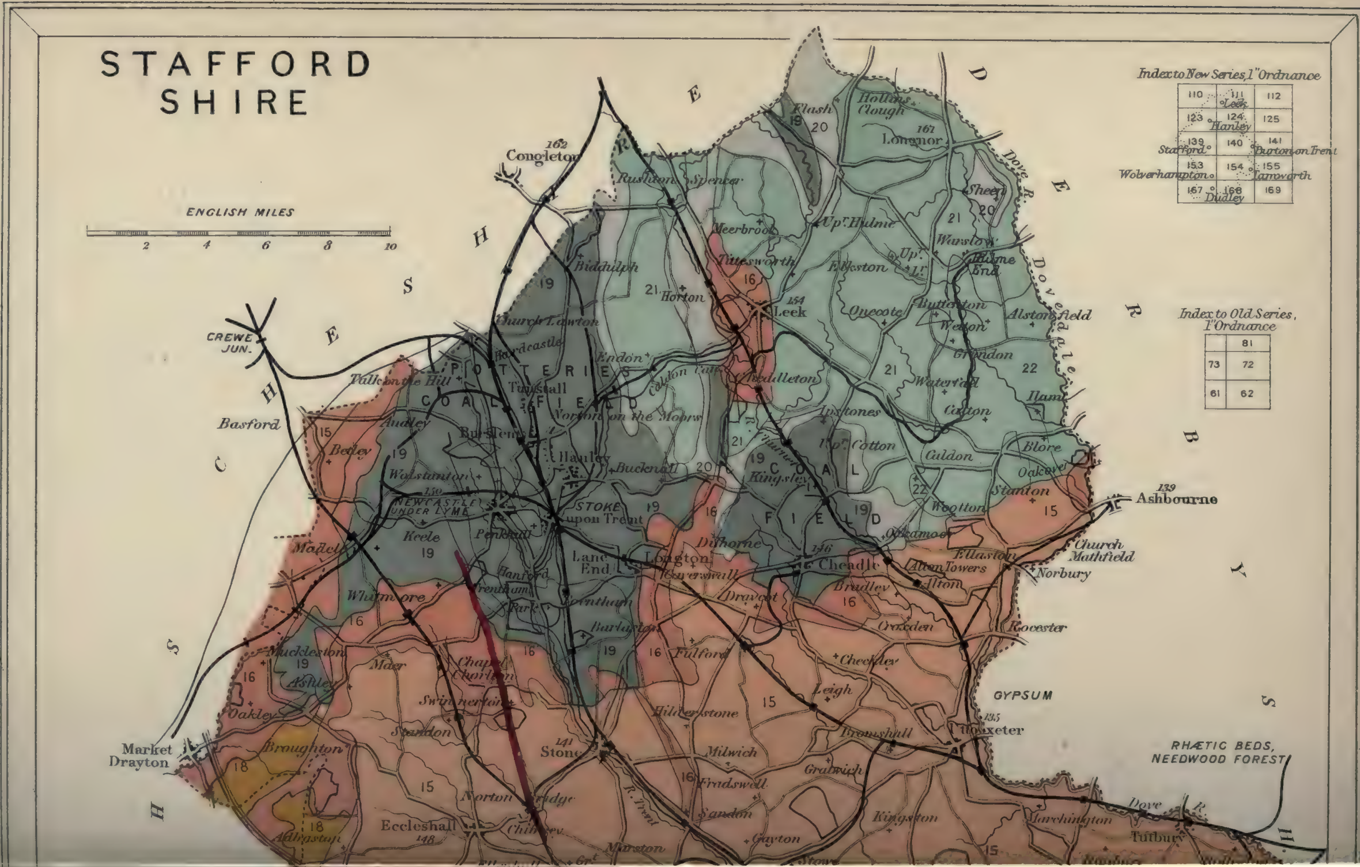
STAFFORD SHIRE
ENGLISH MILES
2 4 6 8 10
Index to New Series, 1" Ordnance
Index to Old Series, 1" Ordnance
Congleton
Crewe Jun.
Basford
Market Drayton
Ashbourne
Leek
Stoke upon Trent
Newcastle under Lyme
Longton
Cheadle
Uttoxeter
Stone
Eccleshall
Tutbury
Potteries Coal Field
Cheadle Coal Field
Dove R.
Dovedale
R. Trent
GYPSUM
RHÆTIC BEDS, NEEDWOOD FOREST
CHESHIRE
DERBYSHIRE

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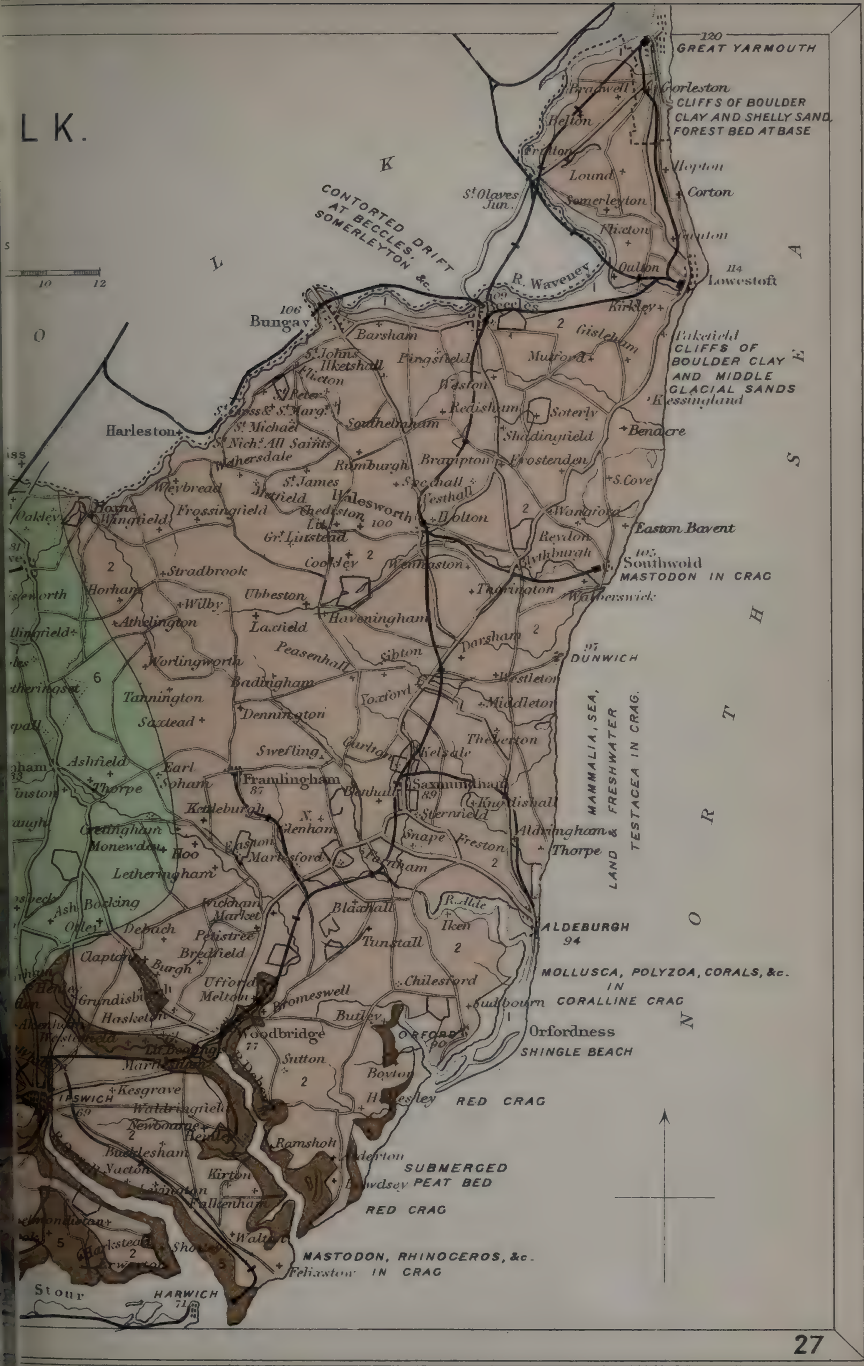
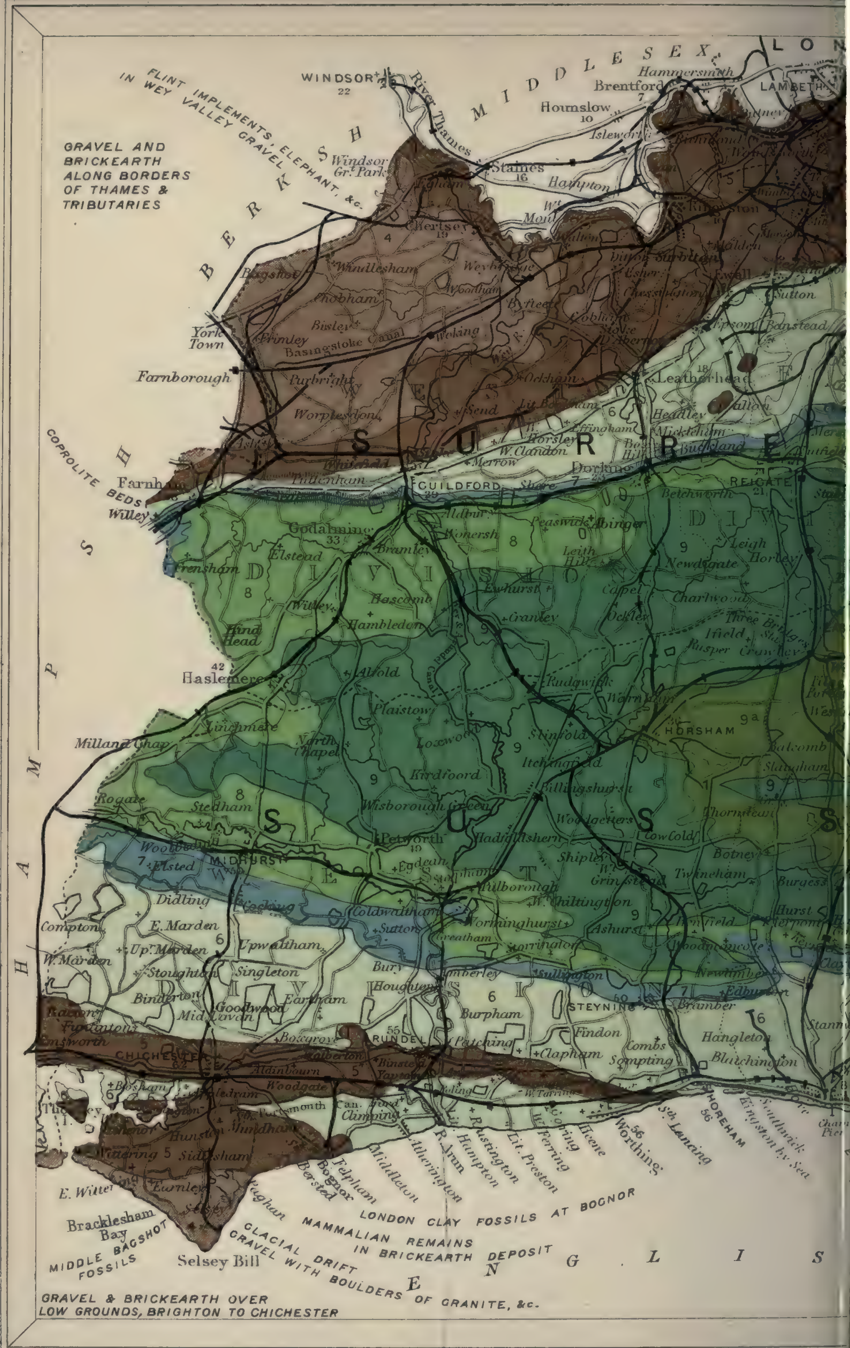
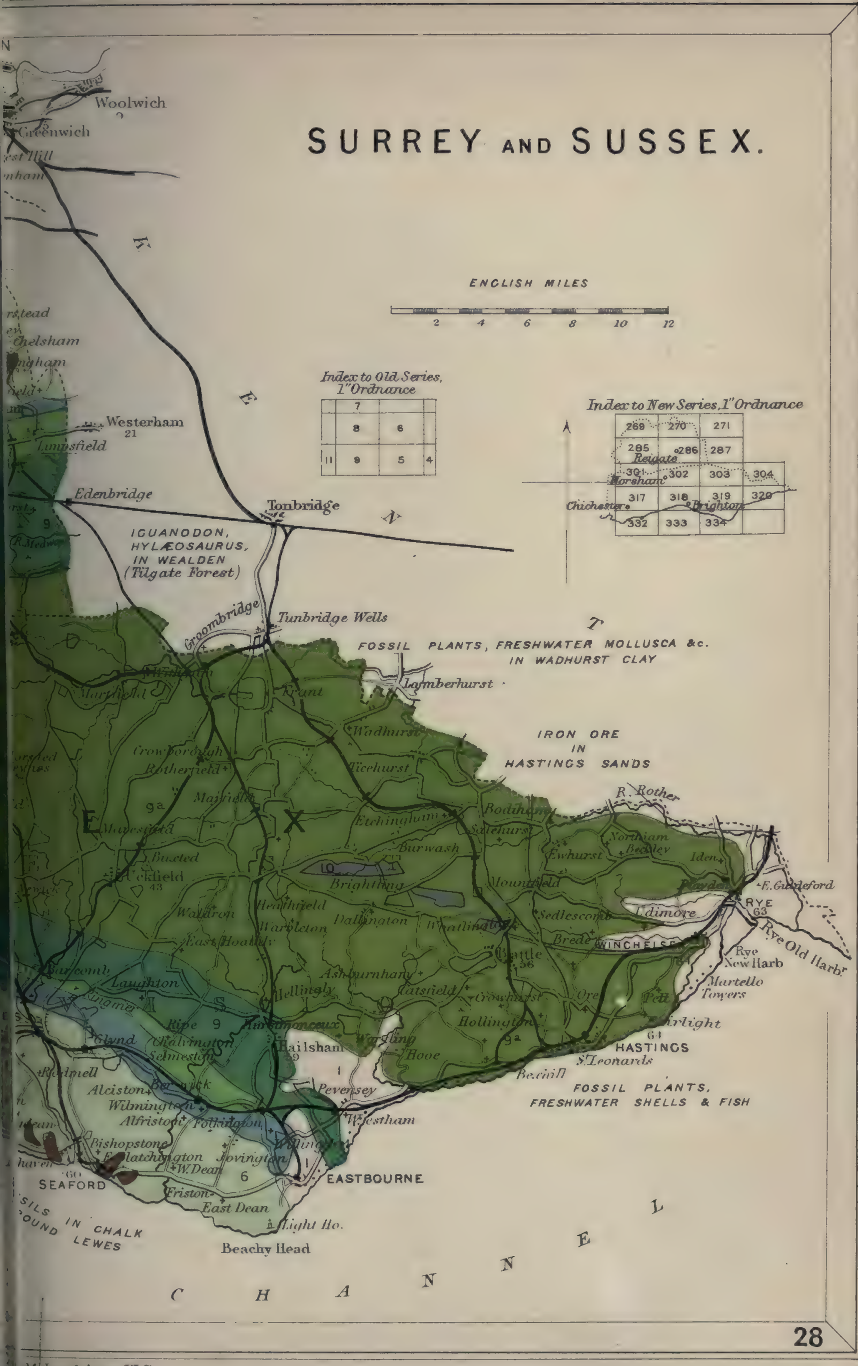
London: Edward S


L K.
GREAT YARMOUTH
Gorleston
CLIFFS OF BOULDER CLAY AND SHELLY SAND, FOREST BED AT BASE
Bradwell
Belton
Fritton
Lound
Hopton
Corton
St. Olaves Jun.
Somerleyton
Flixton
Oulton
CONTORTED DRIFT AT BECCLES, SOMERLEYTON &c.
R. Waveney
Lowestoft
Beccles
Bungay
Kirkley
Gisleham
Pakefield
CLIFFS OF BOULDER CLAY AND MIDDLE GLACIAL SANDS
Kessingland
Barsham
Ilketshall
Ringsfield
Mutford
Weston
Redisham
Sotterly
Benacre
Harleston
Southelmham
Shadingfield
Brampton
Frostenden
S. Cove
Rumburgh
Wissett
Westhall
Weybread
Metfield
Halesworth
Holton
Wangford
Easton Bavent
Hoxne
Wingfield
Frossingfield
Reydon
Blythburgh
Southwold
MASTODON IN CRAG
Cookley
Wenhaston
Stradbrook
Thorington
Walberswick
Horham
Ubbeston
Wilby
Heveningham
Athelington
Laxfield
Darsham
Peasenhall
Sibton
DUNWICH
Worlingworth
Badingham
Westleton
Yoxford
Tannington
Middleton
Dennington
Saxtead
MAMMALIA, SEA, LAND & FRESHWATER TESTACEA IN CRAG.
Theberton
Swefling
Carlton
Kelsale
Ashfield
Earl Soham
Thorpe
Framlingham
Benhall
Saxmundham
Knodishall
Kettleburgh
Sternfield
Glenham
Aldringham
Snape
Friston
Thorpe
Cretingham
Monewden
Hoo
Easton
Marlesford
Farnham
Letheringham
Ash Bocking
R. Alde
Wickham Market
Blaxhall
Iken
ALDEBURGH
Otley
Debach
Petistree
Tunstall
Clopton
Bredfield
Burgh
Chillesford
MOLLUSCA, POLYZOA, CORALS, &c. IN CORALLINE CRAG
Ufford
Grundisburgh
Melton
Bromeswell
Sudbourn
Hasketon
Butley
ORFORD
Orfordness
SHINGLE BEACH
Woodbridge
Westerfield
Sutton
Boyton
IPSWICH
Kesgrave
Hollesley
RED CRAG
Waldringfield
Newbourne
Hemley
Ramsholt
Bucklesham
Alderton
Nacton
Kirton
SUBMERGED PEAT BED
Bawdsey
Falkenham
RED CRAG
Walton
Shotley
MASTODON, RHINOCEROS, &c. IN CRAG
Felixstow
Stour
HARWICH
NORTH SEA



London: Edward S

SURREY AND SUSSEX.

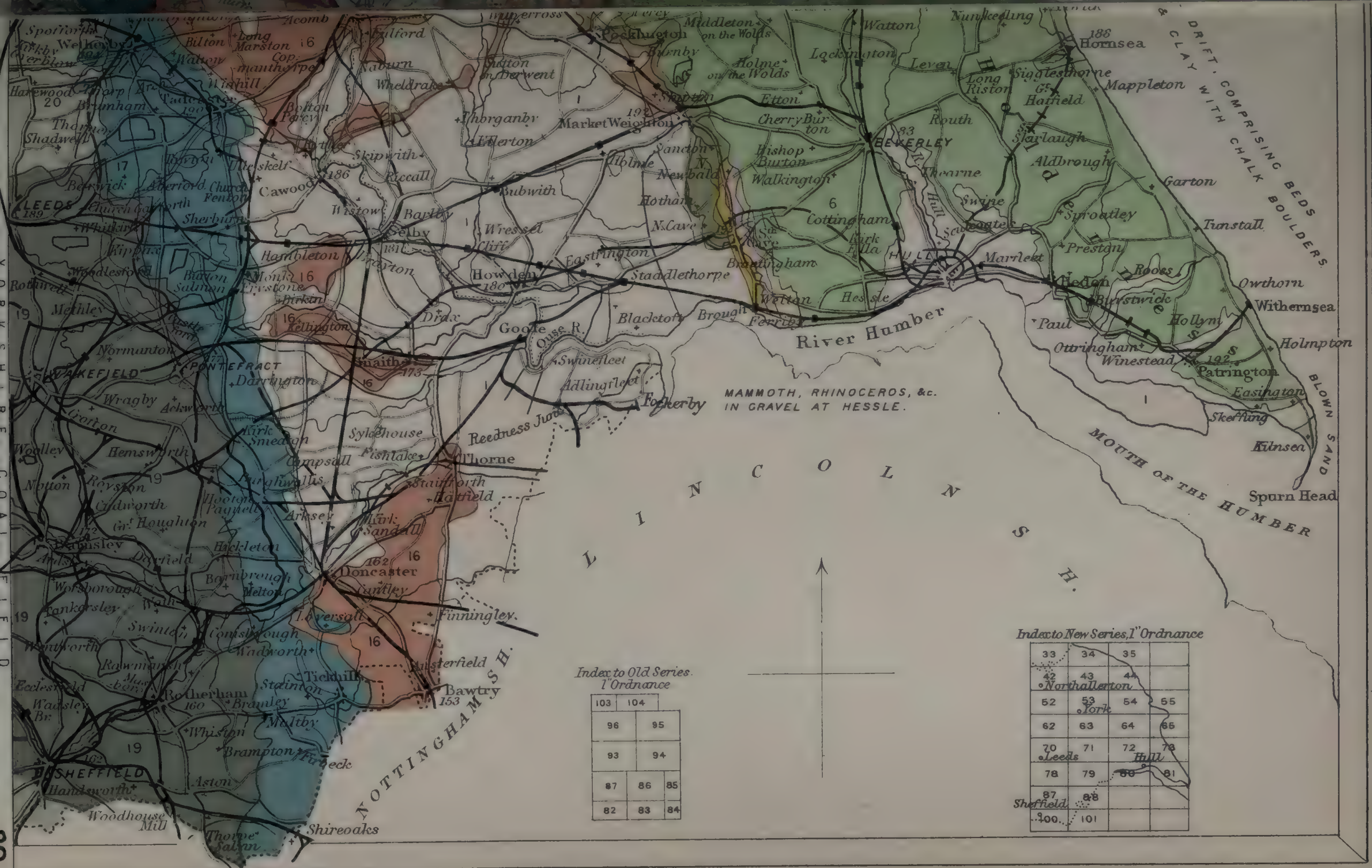


14, Long Acre, W.C.


WARWICKSHIRE
AND
WORCESTERSHIRE.
SILURIAN FOSSILS ABUNDANT IN THE DUDLEY QUARRIES.
ENGLISH MILES.
2 4 6 8 10 12
BRINE SPRINGS AT DROITWICH.
ROCK-SALT AND GYPSUM, IN KEUPER MARLS AT WORCESTER, &c.
STAFFORDSHIRE
SHROPSH.
HEREFORDSH.
WORCESTER
GLOUCE
COAL FD.
Dudley
Stourbridge
Hales Owen
Clent
Northfield
KIDDERMINSTER
BEWDLEY
Cleobury Mortimer
Stourport
Bromsgrove
Tenbury
DROITWICH
WORCESTER
Bromyard
Acton Beauchamp
Gt. Malvern
Lit. Malvern
Hanley Castle
Upton
Pershore
EVESHAM
TEWKESBURY
Ledbury
Pendock
Eldersfield
Chaseley
Staunton
Index to New Series, 1" Ordnance
Dudley
154 155
Atherstone
167 168 169
Birmingham
181 182 183 184
Warwick
Worcester
199 200 201
216 217 218
UP. LLANDOVERY FOSSILS.
FOSSIL FISH & PLANTS IN KEUPER MARLS AT PENDOCK.


SAURIAN BONES IN KEUPER SANDSTONE NEAR WARWICK.
MAMMOTH IN DRIFT AT LEAMINGTON.
HIPPOPOTAMUS, &c. IN DRIFT IN THE AVON VALLEY.
Index to Old Series, 1" Ordnance
62 63
55 54 53
43 44 45
LEICESTERSH.
NORTHAMPTONSH.
OXFORDSH.
WORCESTERSH.
WARWICK
COAL FIELD
TAMWORTH
Newton Regis
Seckington
Polesworth
Wilnecote
Grendon
Atherstone
Merevale
Hartshill
Weddington
Hinckley
Middleton
Sutton Coldfield
Kingsbury
Wishaw
Ansley
Nuneaton
Stockingford
Whitacre
Water Orton
Calvers Coton
Burton Hastings
Bromwich
Shustoke
Astley
Fillongley
Coleshill
Bulkington
Wolvey
Wibtoft
Bedworth
Lutterworth
Maxstock
Corley
Withybrook
Marston
Sheldon
Packington
Exhall
Shilton
Foleshill
Pailton
Bickinhill
Meriden
Hampton in Arden
Solihull
Allesley
Brinklow
Sow
Stretton
Berkswell
COVENTRY
Stoke
Brownsover
Knowle
Binley
Harborough
Dockers La
Clifton
Temple Balsall
Stivichall
Newbold
Rugby
Baginton
Wolston
Kenilworth
Bilton
Stoneleigh
Dunchurch
Honily
Stretton
Leek Wootton
Ashow
Weston
Tanworth
Lapworth
Wroxall
Baddesley Clinton
Haseley
Marton
Ullenhall
Milverton
Lillington
Cubbington
Grandborough
Henley in Arden
Leamington
WARWICK
Offchurch
Whitnash
Claverdon
Norton Lindsey
Southam
Shuckburgh
Ufton
Daventry
Wootton Wawen
Bishops Tachbrook
Wolverton
Ladbrook
Napton
Bearley
Marston
Harbury
Priors Hardwick
Gr. Alne
Kinwarton
Wilmcote
Snitterfield
Haselor
Hampton Lucy
Alveston
Lightborne
Billesley
Wellesbourn Hastings
Binton
Stratford on Avon
Gardon
Kineton
Fenny Compton
Burton Dassett
Farnborough
Butlers Marston
Up. Eatington
Ratley
Warmington
Atherstone
Whitchurch
Halford
Oxhill
Idlicote
Church Tysoe
Ilmington
Tredington
Shipston on Stour
Brailes
Chipping Campden
Stretton
Burmington
Paxford
Tidmington
Cherrington
Whichford
Long Compton
Blockley
Barton
Moreton in the Marsh
Evenload
Oxford Can.
Birmingham and Fazeley Can.
Stratford on Avon Can.


EAST YORKSHIRE.
ENGLISH MILES
2 4 6 8 10 12 14 16
IRON ORES IN MIDDLE LIAS OF CLEVELAND
BED OF ROCK SALT 100 FT THICK AT MIDDLESBORO AT A DEPTH OF 1200 FT
ROCK SALT IN KEUPER
LOWER LIAS
THIN SEAMS OF IRON PYRITES,
MIDDLE LIAS
IMPURE COAL, JET, FOSSIL PLANTS.
UPPER LIAS FOSSILS AT WHITBY
ALUM SHALE IN UPPER LIAS
AMMONITES. PLANTS IN SANDSTONE
FOSSIL FERNS AND CYCADS IN SANDSTONE
AMMONITES, BELEMNITES, &c.
CORALS ABUNDANT AT HACKNESS.
FOSSIL PLANT BED.
SEPTARIA, COPROLITES, &c. IN SPEETON CLAY.
RED CHALK
CHALK.
LARGE FLINTS.
FOSSIL SPONGES.
D U R H A M
N O R T H
Mouth of the Tees
Redcar
Marske
Saltburn
Middlesbo
Stockton 241
Thornaby
Yarm
Stokesley
Guisborough
Lofthouse
Hinderwell
Ellerby
Lythe
WHITBY 236
Egton
Danby
Glaisdale
Westerdale
Cleveland Hills
Goathland
Robin Hoods Bay
Harwood Dale
Y O R K M O O R S
Rosedale
Farndale
Bransdale
Bilsdale
Osmotherly
NORTH ALLERTON 225
THIRSK 217
Helmsley
Pickering 226
Vale of Pickering
SCARBOROUGH 217
Filey
Hunmanby
Reighton
Speeton
Bempton
Flamborough Head
Bridlington 206
Bridlington Bay
NEW MALTON 217
Easingwold
Boroughbridge
RIPON
Aldborough
Sledmere
Kilham
Rudston
Driffield



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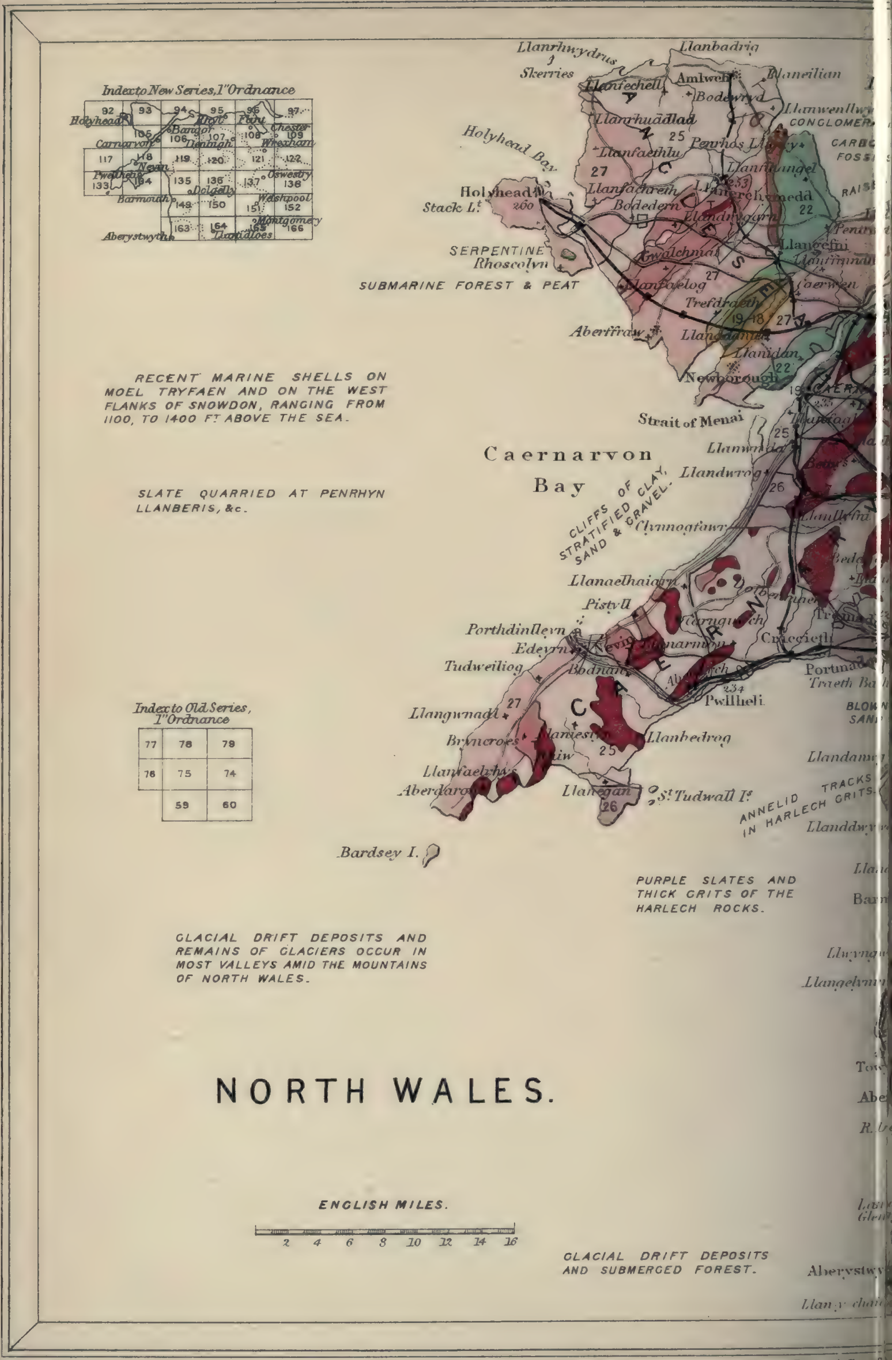
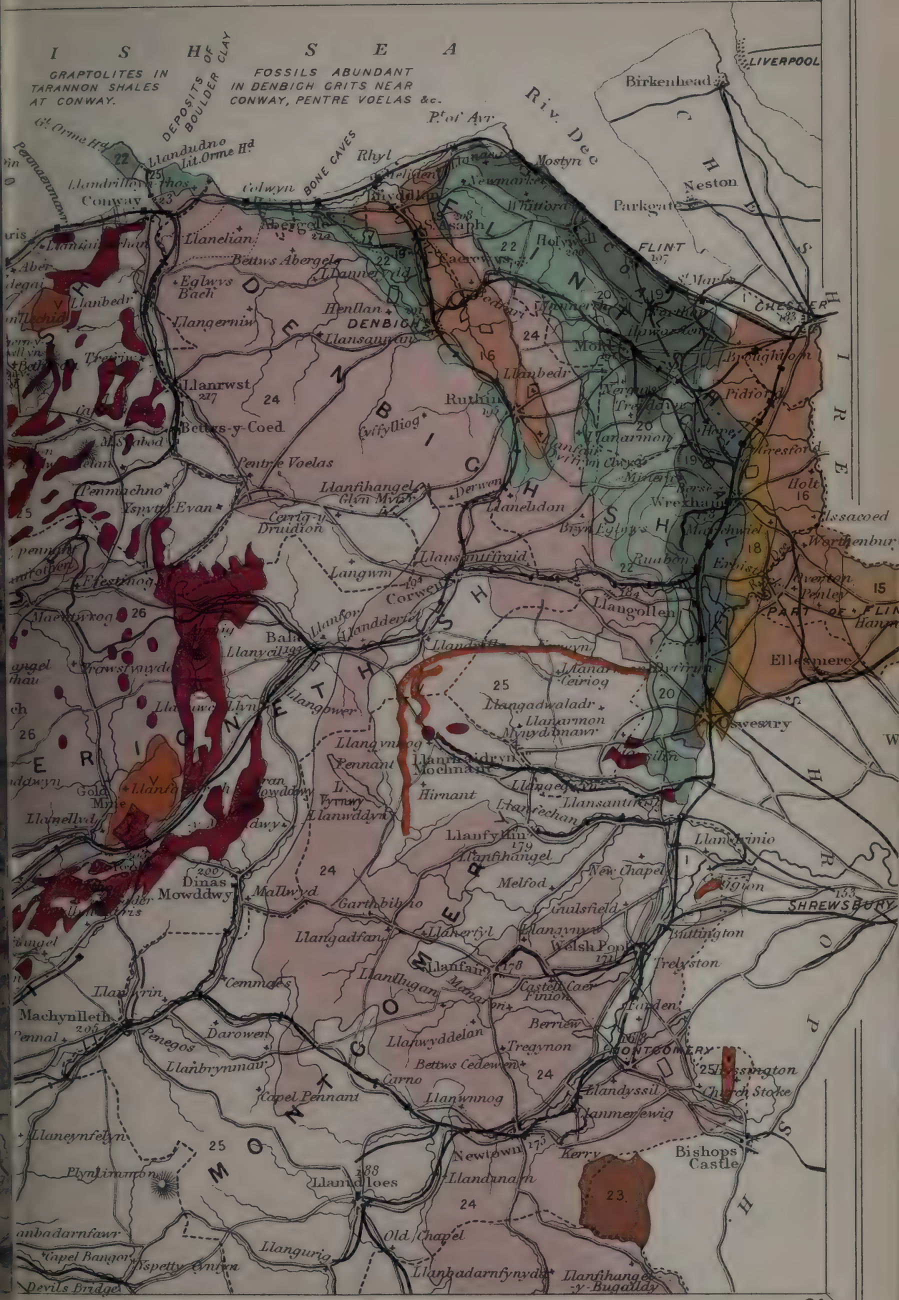
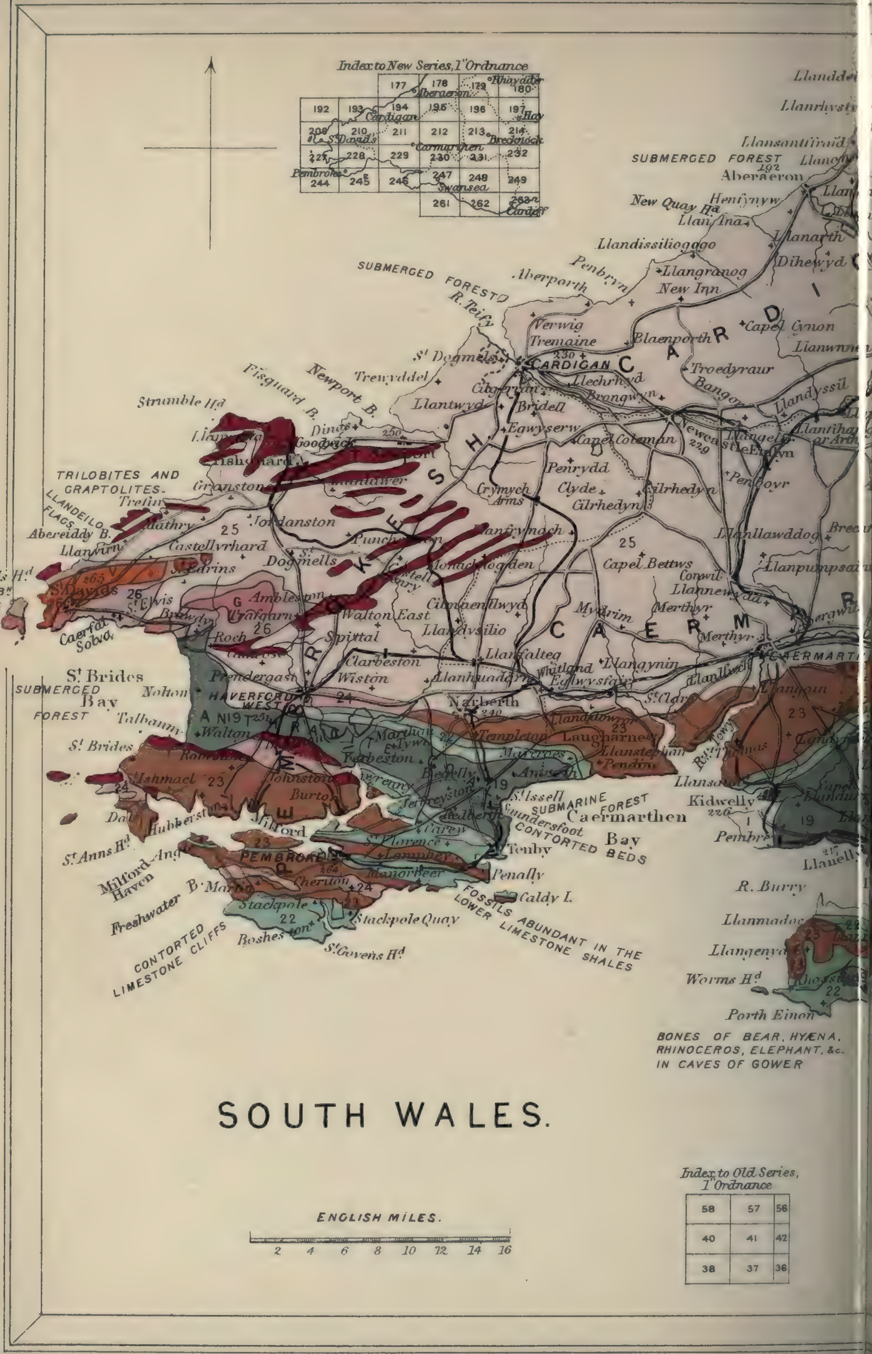

Index to New Series, 1" Ordnance
Index to Old Series, 1" Ordnance
RECENT MARINE SHELLS ON MOEL TRYFAEN AND ON THE WEST FLANKS OF SNOWDON, RANGING FROM 1100, TO 1400 FT. ABOVE THE SEA.
SLATE QUARRIED AT PENRHYN LLANBERIS, &c.
SERPENTINE
SUBMARINE FOREST & PEAT
CLIFFS OF STRATIFIED CLAY, SAND & GRAVEL.
ANNELID TRACKS IN HARLECH GRITS.
PURPLE SLATES AND THICK GRITS OF THE HARLECH ROCKS.
GLACIAL DRIFT DEPOSITS AND REMAINS OF GLACIERS OCCUR IN MOST VALLEYS AMID THE MOUNTAINS OF NORTH WALES.
GLACIAL DRIFT DEPOSITS AND SUBMERGED FOREST.
Holyhead Bay
Caernarvon Bay
Strait of Menai
Bardsey I.
St. Tudwall Is.
NORTH WALES.
ENGLISH MILES.
2 4 6 8 10 12 14 16


GRAPTOLITES IN TARANNON SHALES AT CONWAY.
DEPOSITS OF BOULDER CLAY
FOSSILS ABUNDANT IN DENBIGH GRITS NEAR CONWAY, PENTRE VOELAS &c.
BONE CAVES
LIVERPOOL
Birkenhead
Riv. Dee
Neston
Parkgate
Mostyn
Rhyl
Llandudno
Lit. Orme Hd
Conway
Colwyn
Abergele
St. Asaph
Holywell
FLINT
Llanelian
Bettws Abergele
Eglwys Bach
Llanbedr
Llangernin
Henllan
DENBIGH
Llansannan
Llanrwst
Bettws-y-Coed
Pentre Voelas
Penmachno
Ruthin
Cyffylliog
Mold
CHESTER
Broughton
Pidford
Hope
Gresford
Holt
Wrexham
Llanarmon
Llanelidon
Derwen
Llanfihangel Glyn Myfyr
Cerrig-y-Druidion
Festiniog
Maentwrog
Trawsfynydd
Bala
Llanycil
Llanfor
Llandderfel
Llangower
Corwen
Langwm
Llansantffraid
Llangollen
Ruabon
Ellesmere
Overton
Penley
Worthenbury
Bangor Isycoed
PART OF FLINT
Llangadwaladr
Llanarmon Mynydd mawr
Llangynog
Pennant
Llanrhaiadr yn Mochnant
Hirnant
Llanwddyn
Llanfyllin
Llanfihangel
Oswestry
Llansantffraid
Llanfechan
Llandrinio
New Chapel
Melfod
Guilsfield
Welsh Pool
Buttington
Trelyston
SHREWSBURY
Dinas Mowddwy
Mallwyd
Garthbibio
Llangadfan
Llanerfyl
Llanfair
Llanllugan
Castell Caer Finion
Berriew
Forden
MONTGOMERY
Cemmaes
Llanwrin
Machynlleth
Pennal
Penegos
Darowen
Llanbrynmair
Carno
Llanwnnog
Tregynon
Bettws Cedewen
Llandyssil
Llanmerewig
Church Stoke
Bishops Castle
Kerry
Newtown
Capel Pennant
Llaneynfelyn
Plynlimmon
Llanidloes
Llandinam
Old Chapel
Llangurig
Llanbadarnfawr
Capel Bangor
Yspetty Cynfyn
Devils Bridge
Llanbadarnfynydd
Llanfihangel-y-Bugaildy
DENBIGH SHIRE
FLINT
MERIONETH
MONTGOMERY
SHROPSHIRE
CHESHIRE
IRISH SEA



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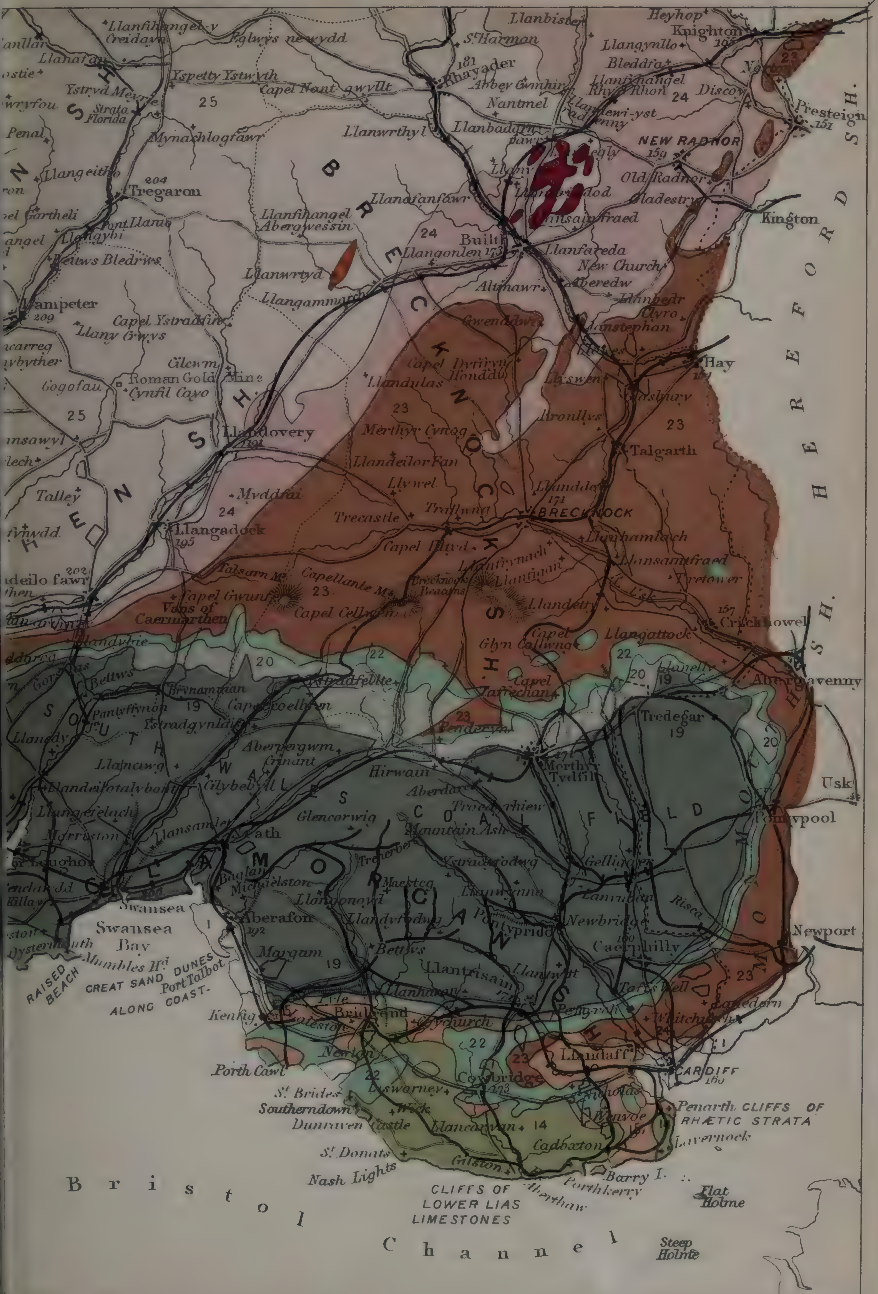
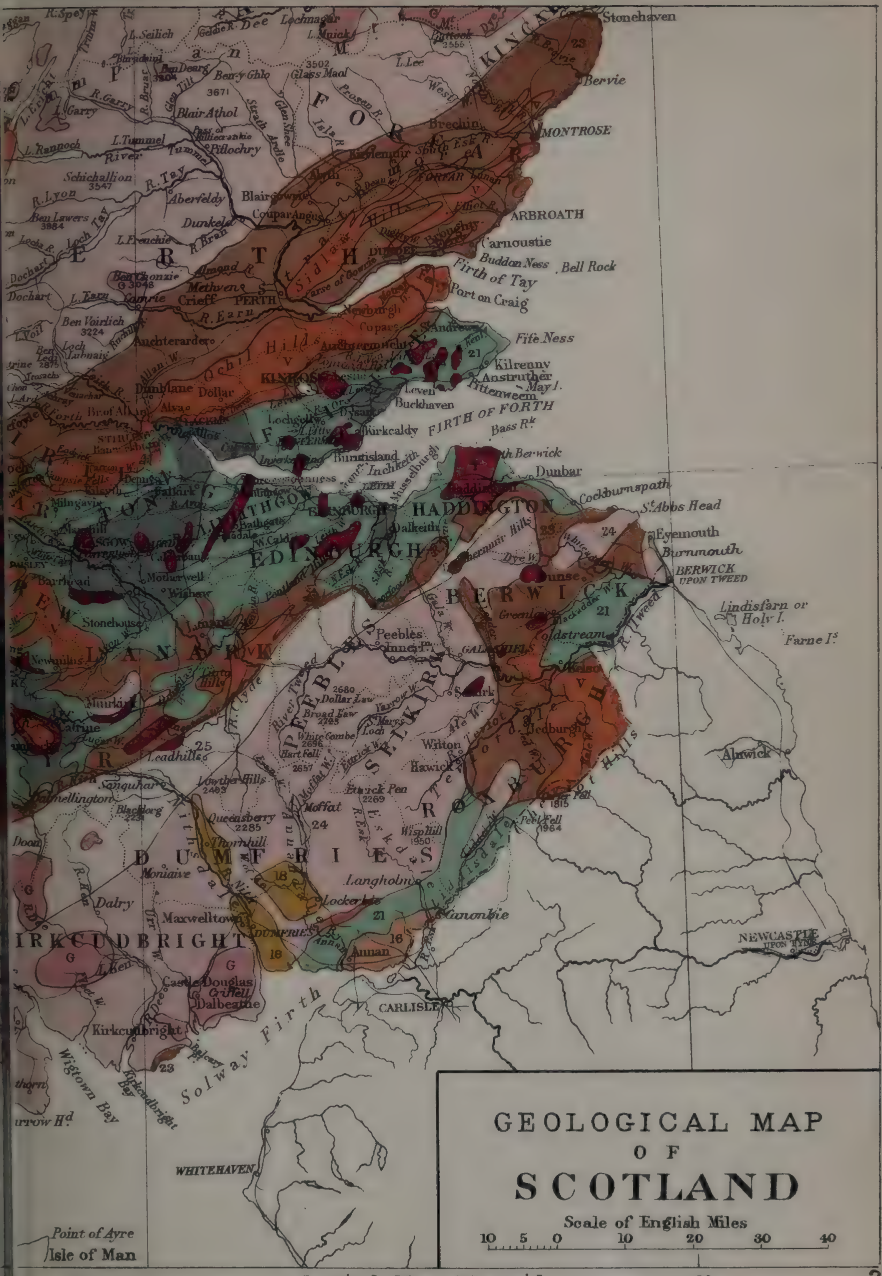


, 13 & 14, Long Acre, W.C.

London : Edward Stanf

3 & 14, Long Acre, W.C.
Stanfords Geogl. Estabt. London

London: Edward Stanf



13 & 14, Long Acre, W.C.

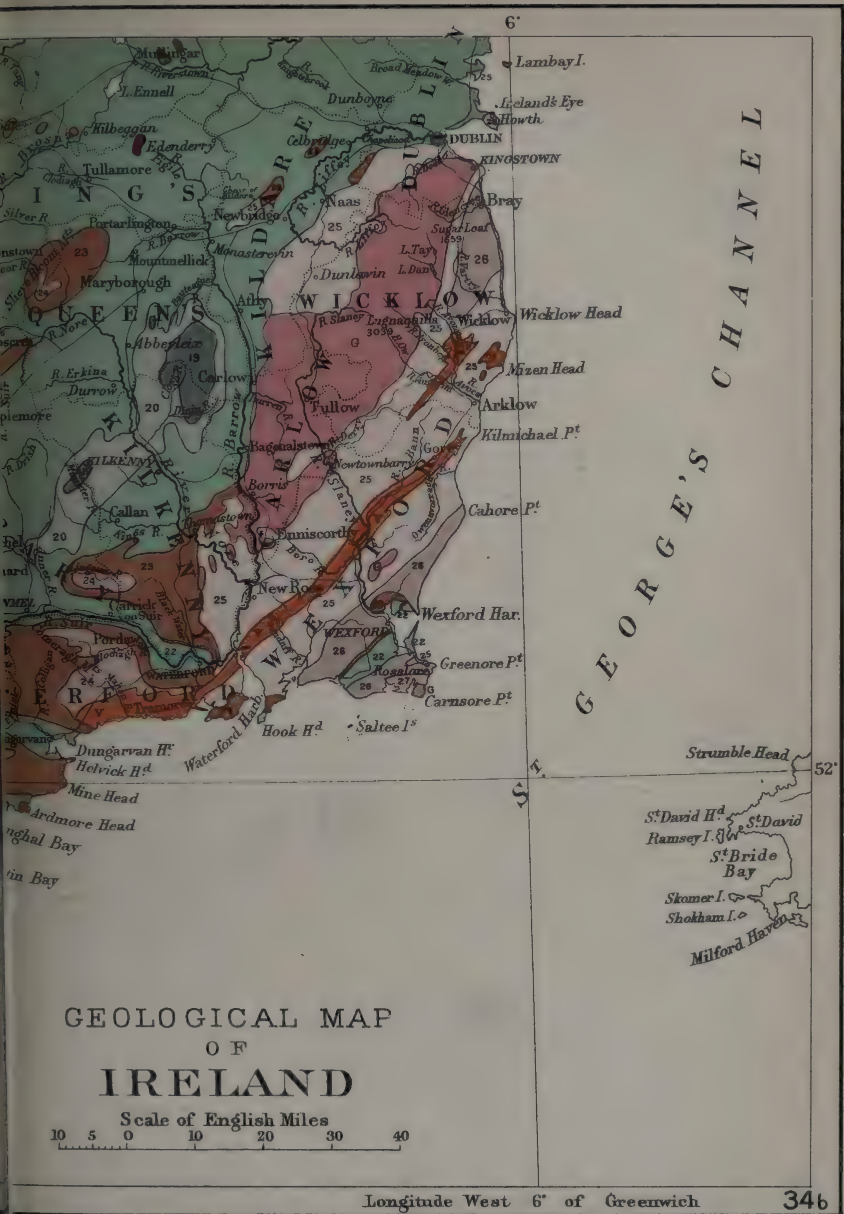
Stanford's Geogl. Estabt. London

London : Edward Stanfor

3 & 14, Long Acre, W.C.

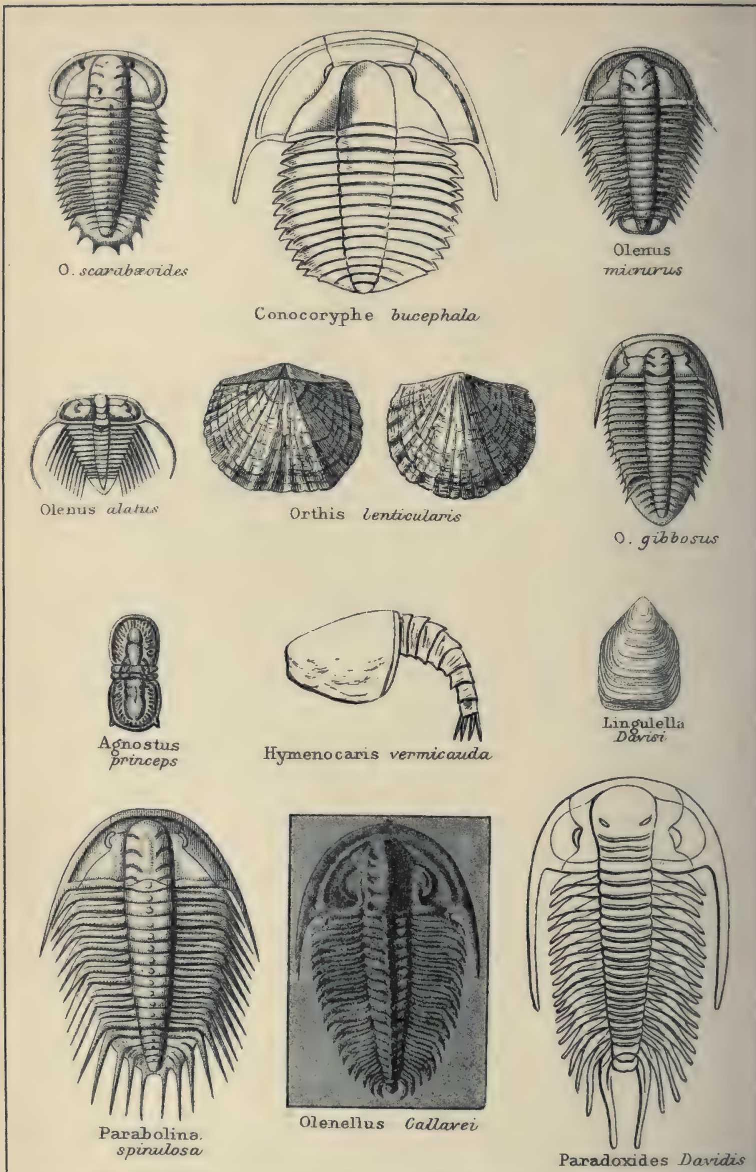
Stanford's Geogl. Estabt., London.

London: Edward Stanfo



4, Long Acre, W.C.
Stanford's Geog. Estab.t, London

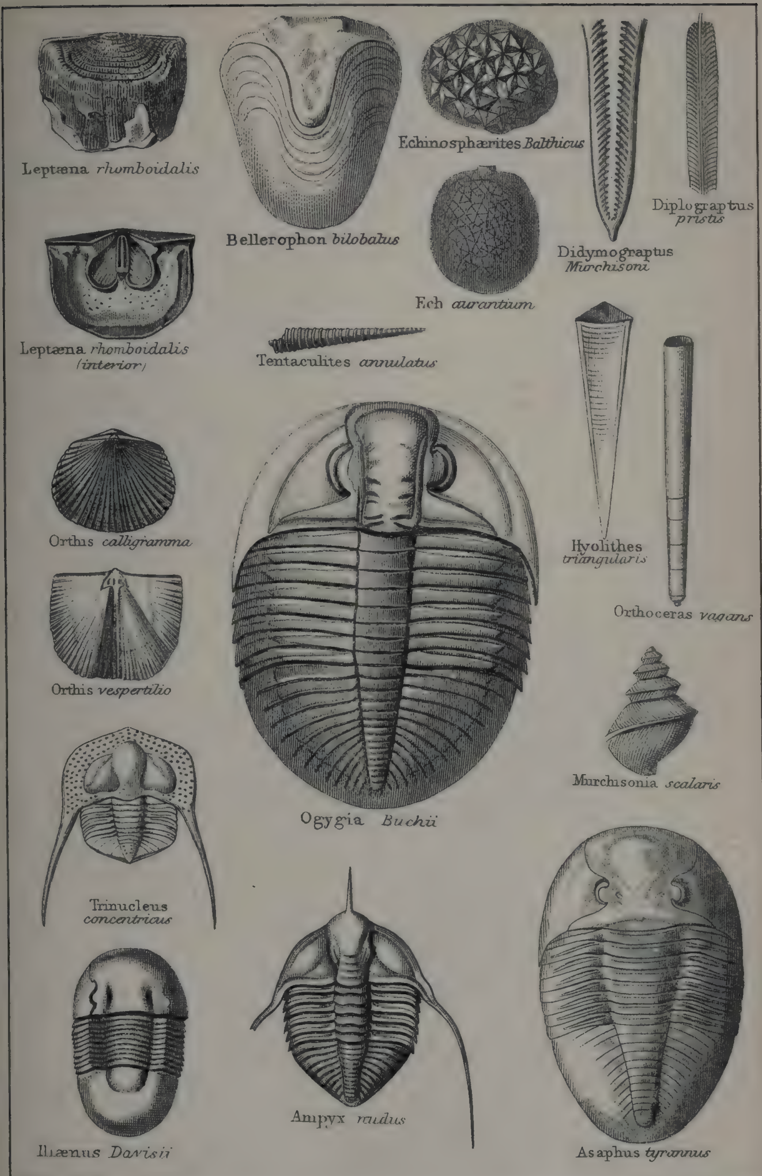
CAMBRIAN



Stanford's Geog. Estab.

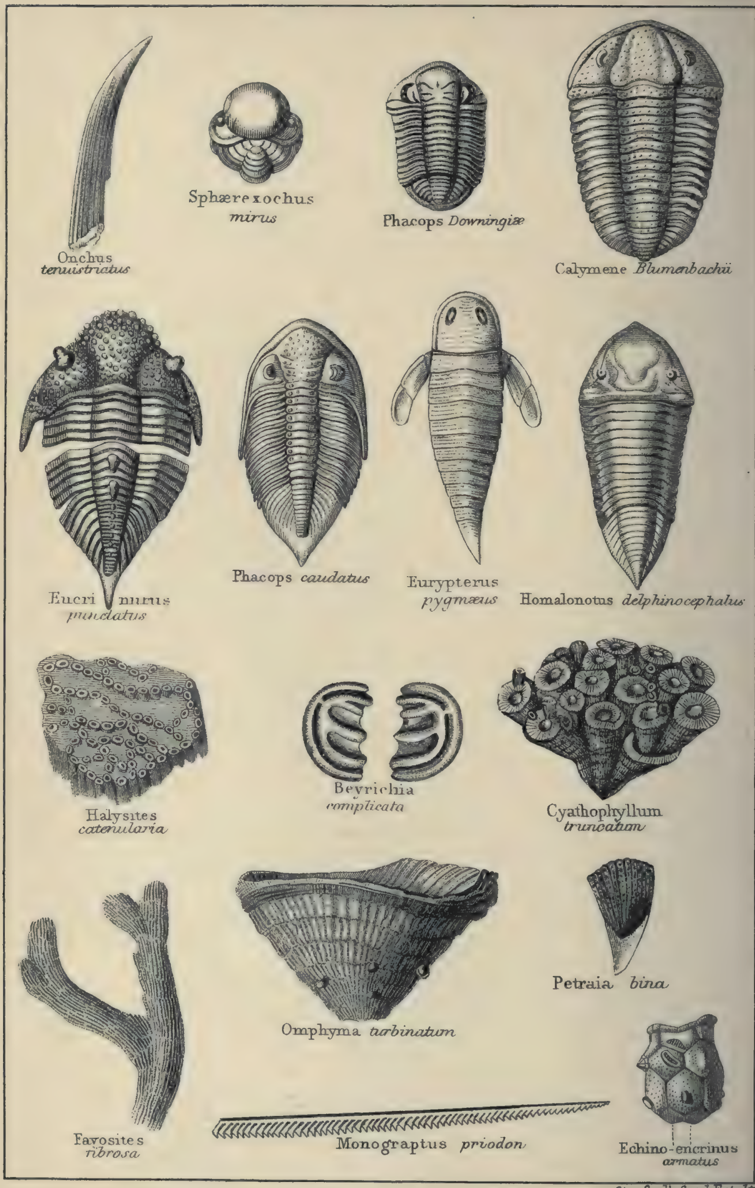
Harlech, Menevian, Lingula Flag & Tremadoc Series.

ORDOVICIAN



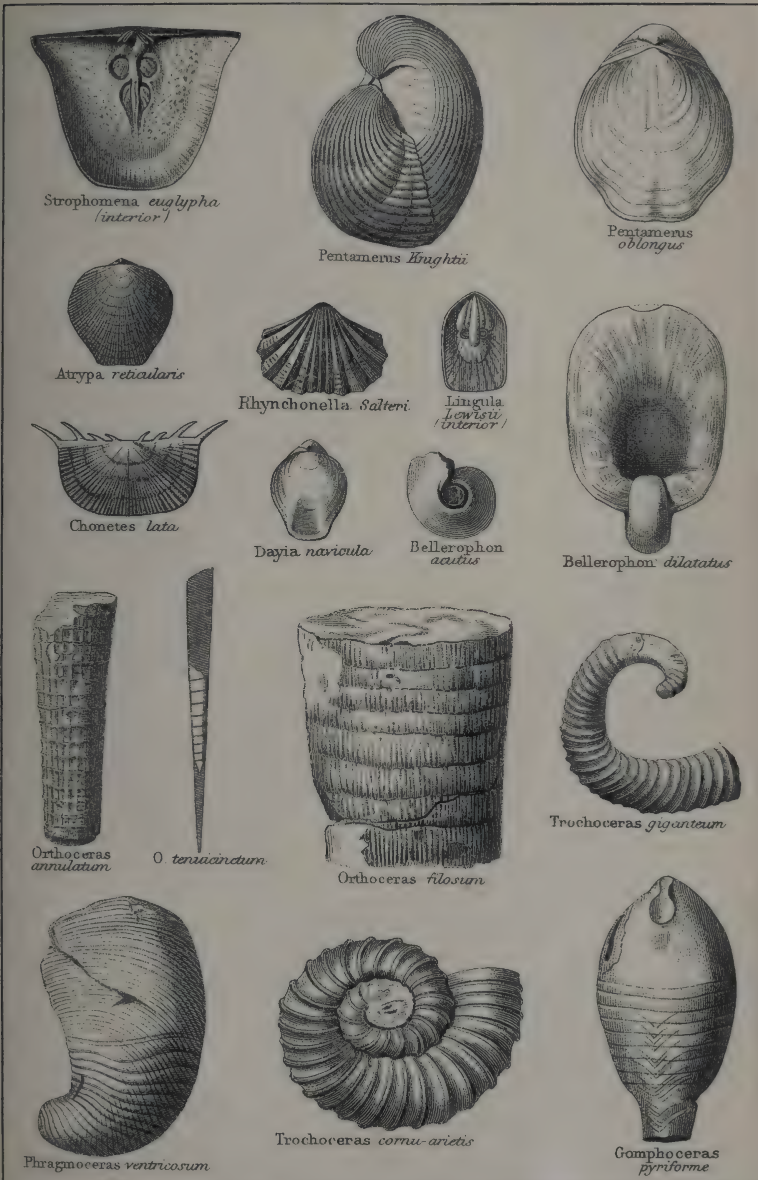
Arenig, Llandeilo & Bala Series.

SILURIAN



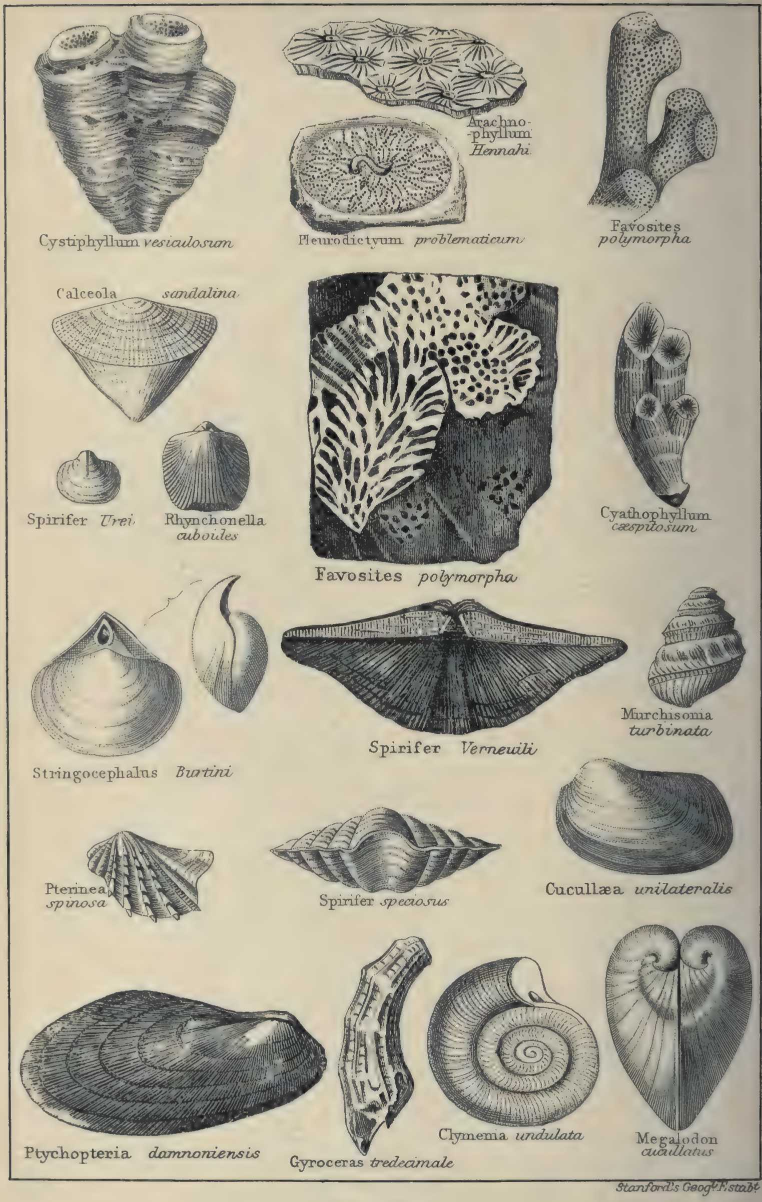
Llandovery, Wenlock & Ludlow Series.

SILURIAN



Llandovery, Wenlock & Ludlow Series.

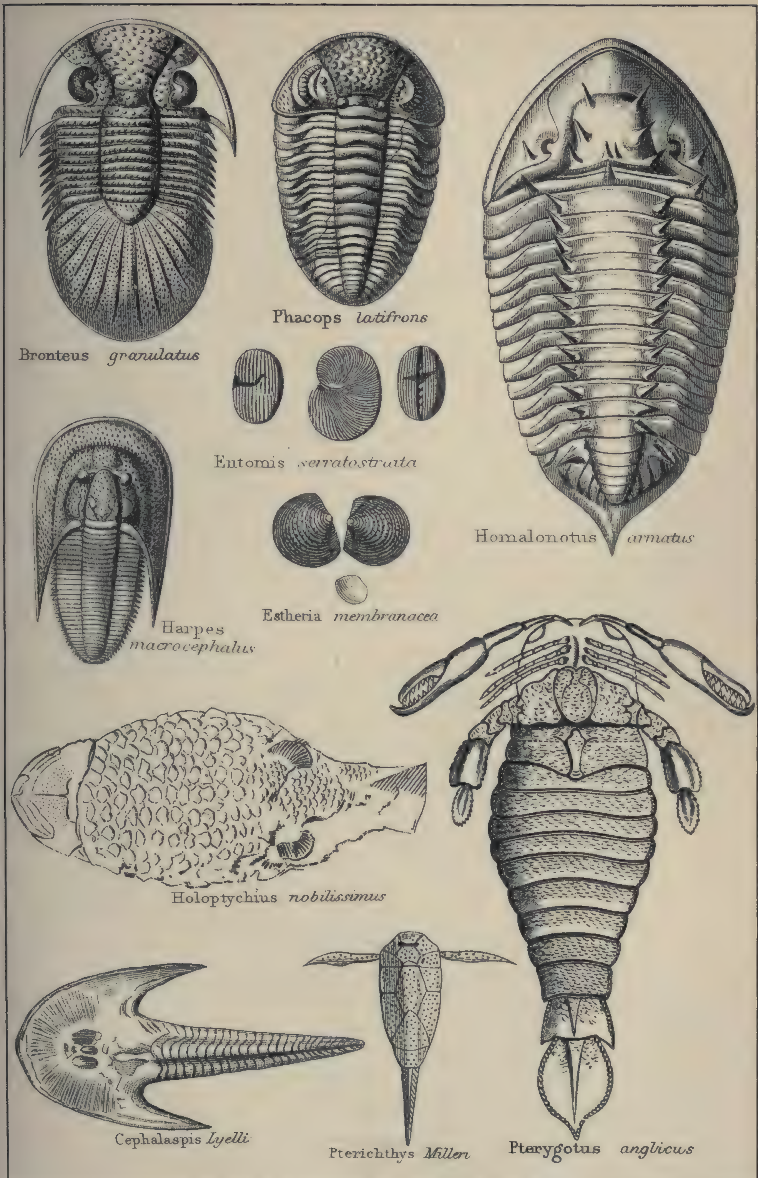
DEVONIAN



Stanford's Geog^l. Estab^t.

Devonian.

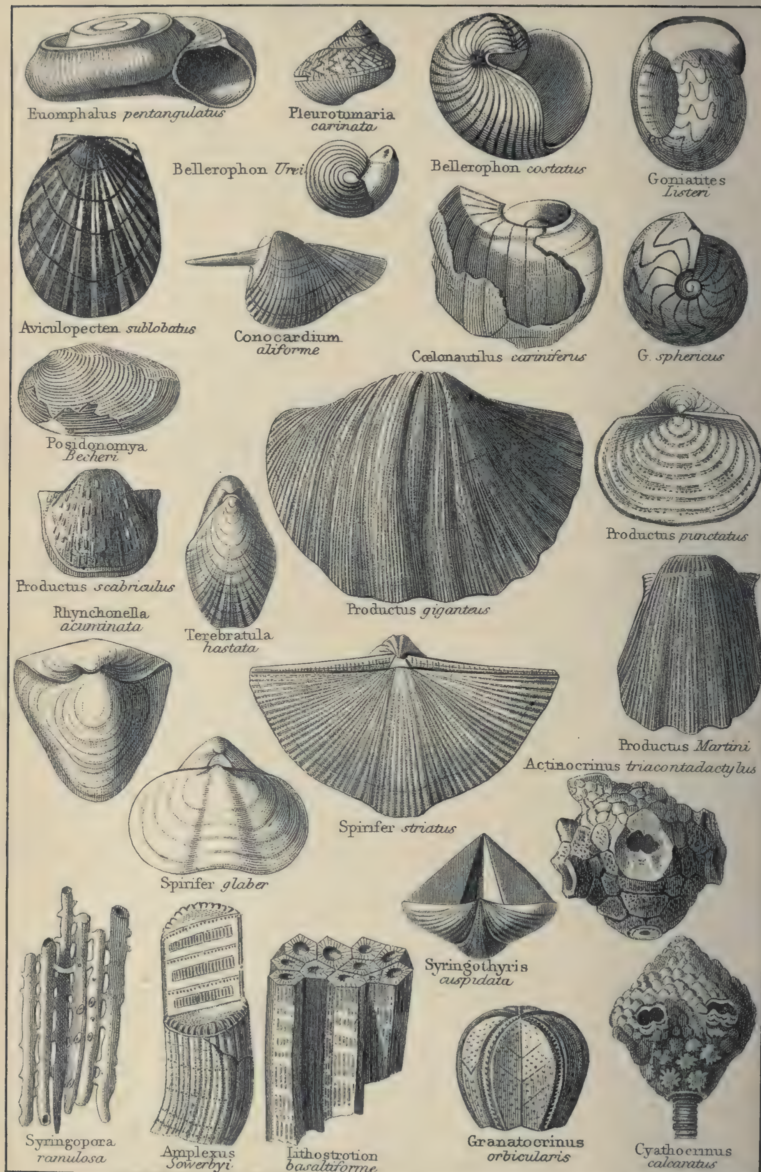
DEVONIAN & OLD RED SANDSTONE



Stanford's Geog

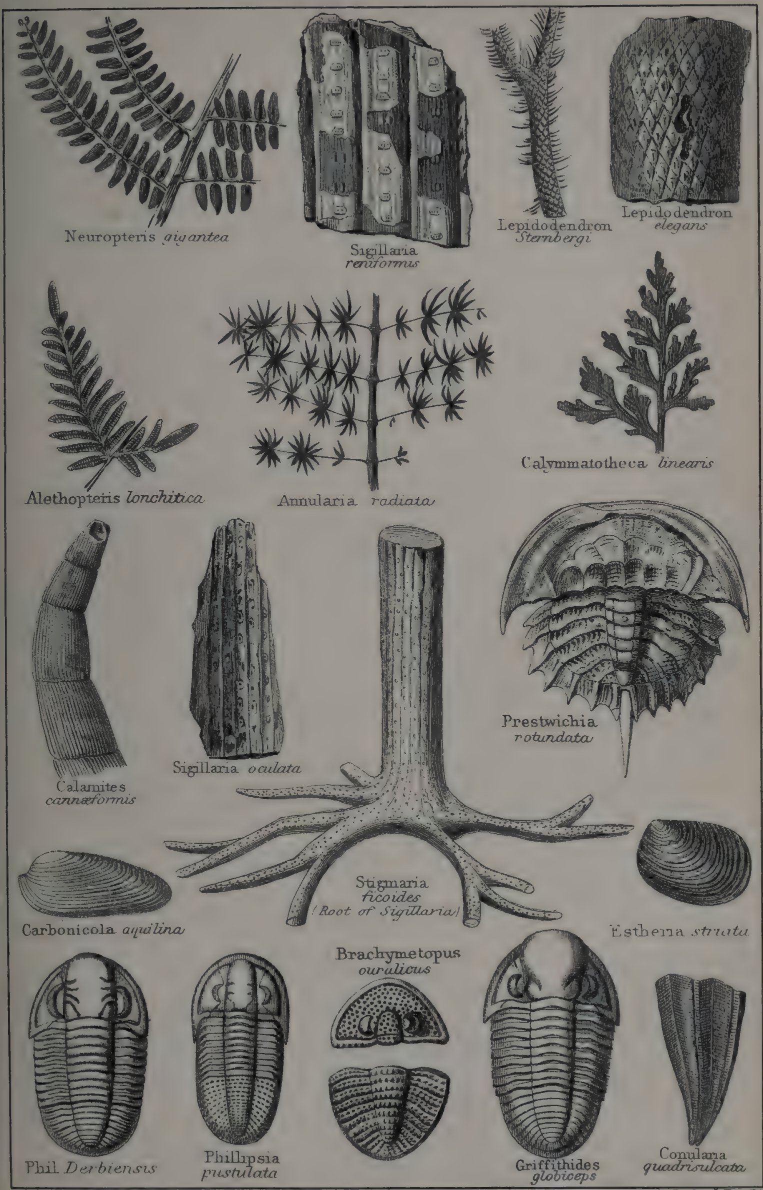
Devonian & Old Red Sandstone.

CARBONIFEROUS



Carboniferous Limestone Series.

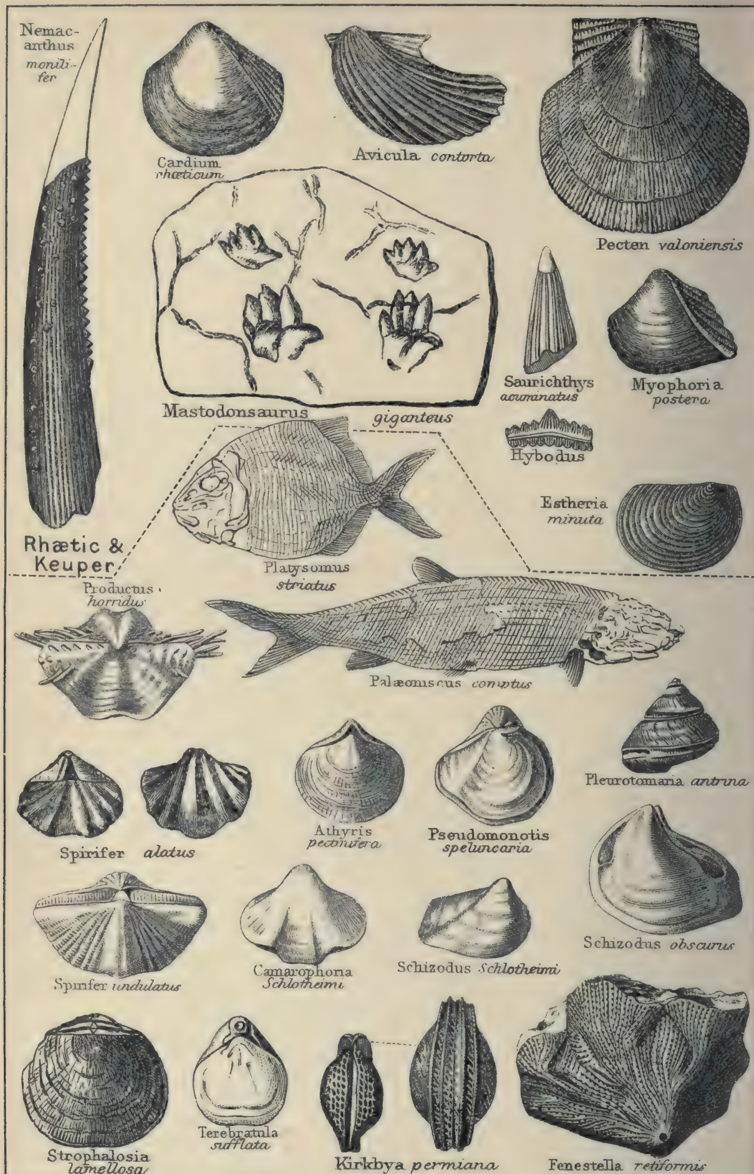
CARBONIFEROUS



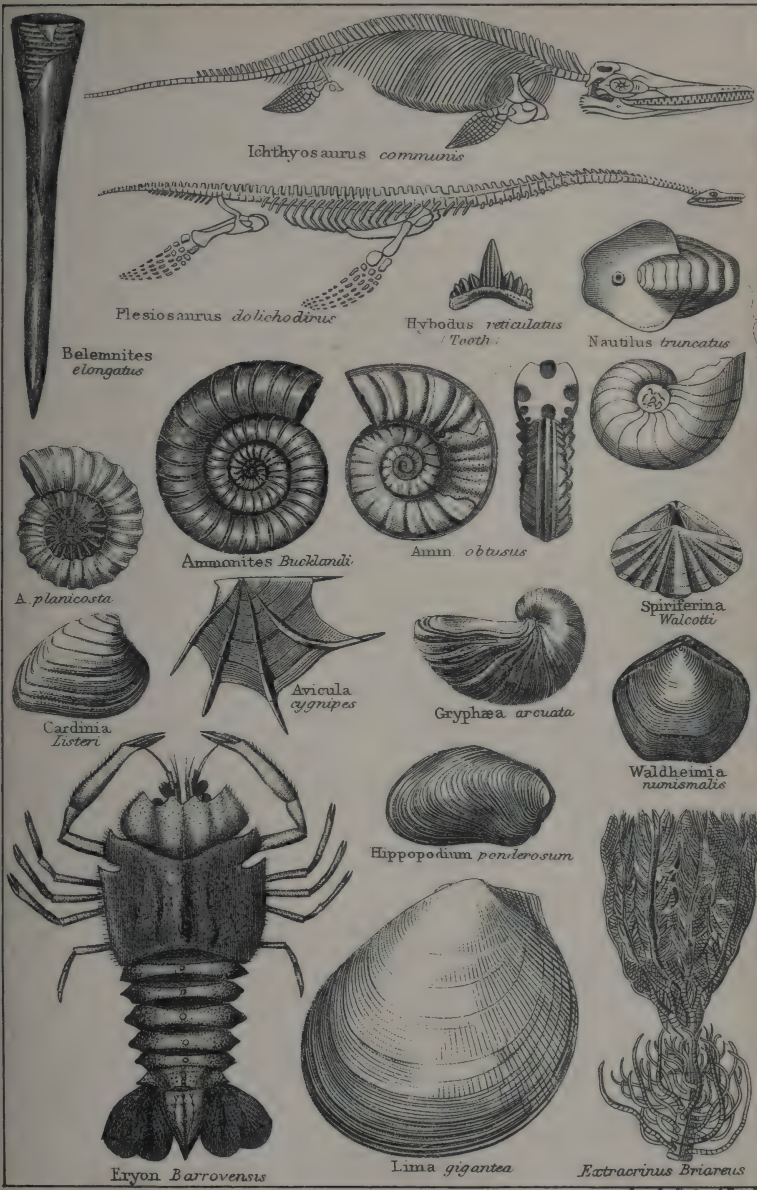
Stanford's Geog.[l] Estab.[t]

Carboniferous Limestone Series & Coal Measures.

TRIASSIC & PERMIAN

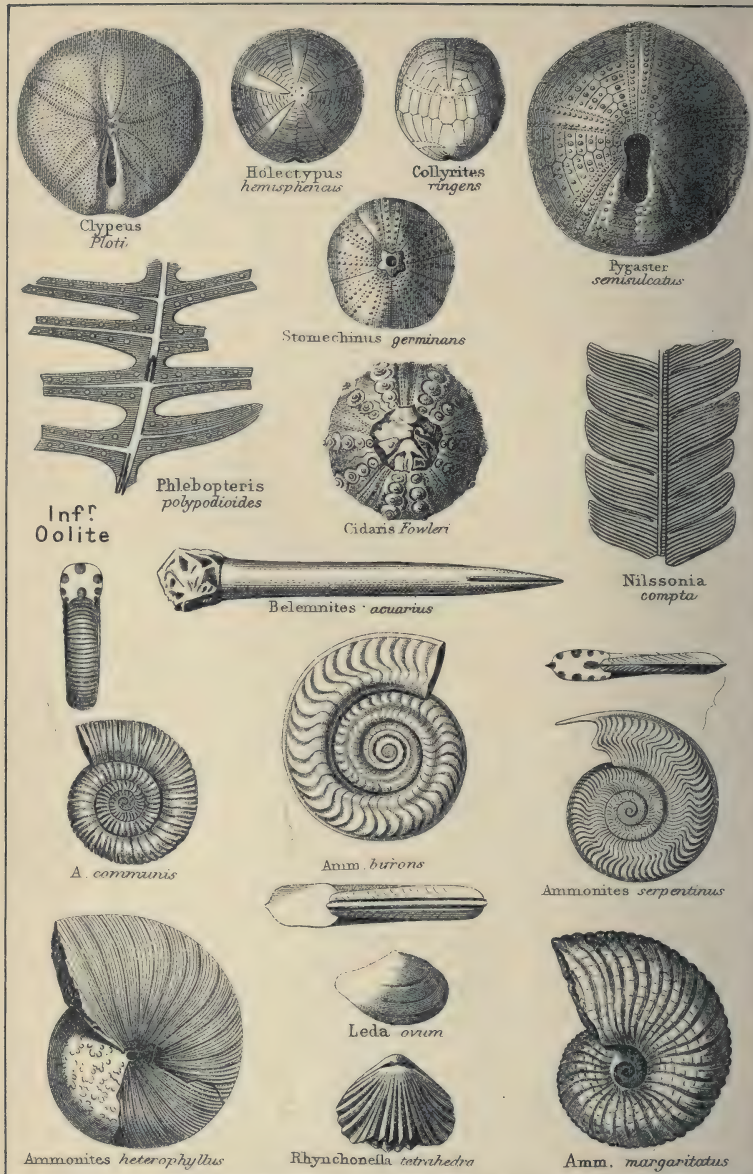


Magnesian Limestone.

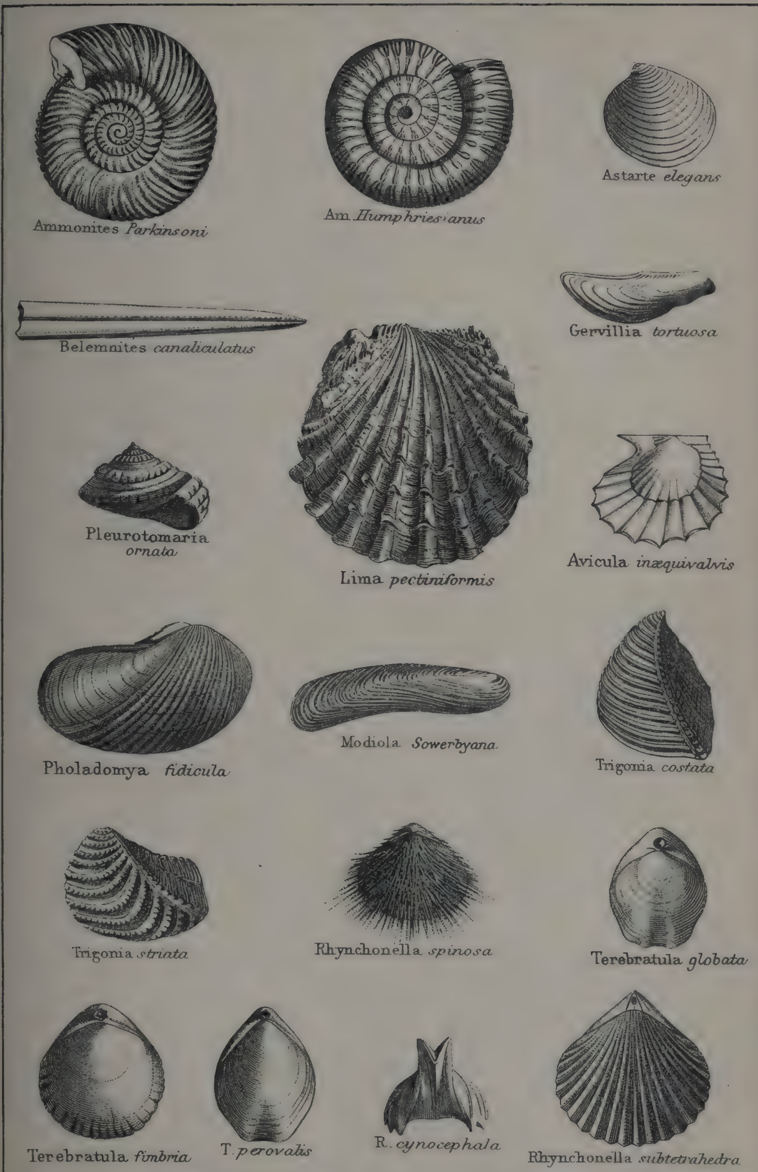

Ichthyosaurus *communis*
Plesiosaurus *dolichodirus*
Belemnites *elongatus*
Hybodus *reticulatus*
(Tooth)
Nautilus *truncatus*
Ammonites *Bucklandi*
Amm. *obtusus*
A. *planicosta*
Spiriferina *Walcotti*
Avicula *cygnipes*
Gryphæa *arcuata*
Cardinia *Listeri*
Waldheimia *numismalis*
Hippopodium *ponderosum*
Eryon *Barrovensis*
Lima *gigantea*
Extracrinus Briareus
Stanford's Geog! Estab!

Lower Lias.

LOWER OOLITIC & LIASSIC



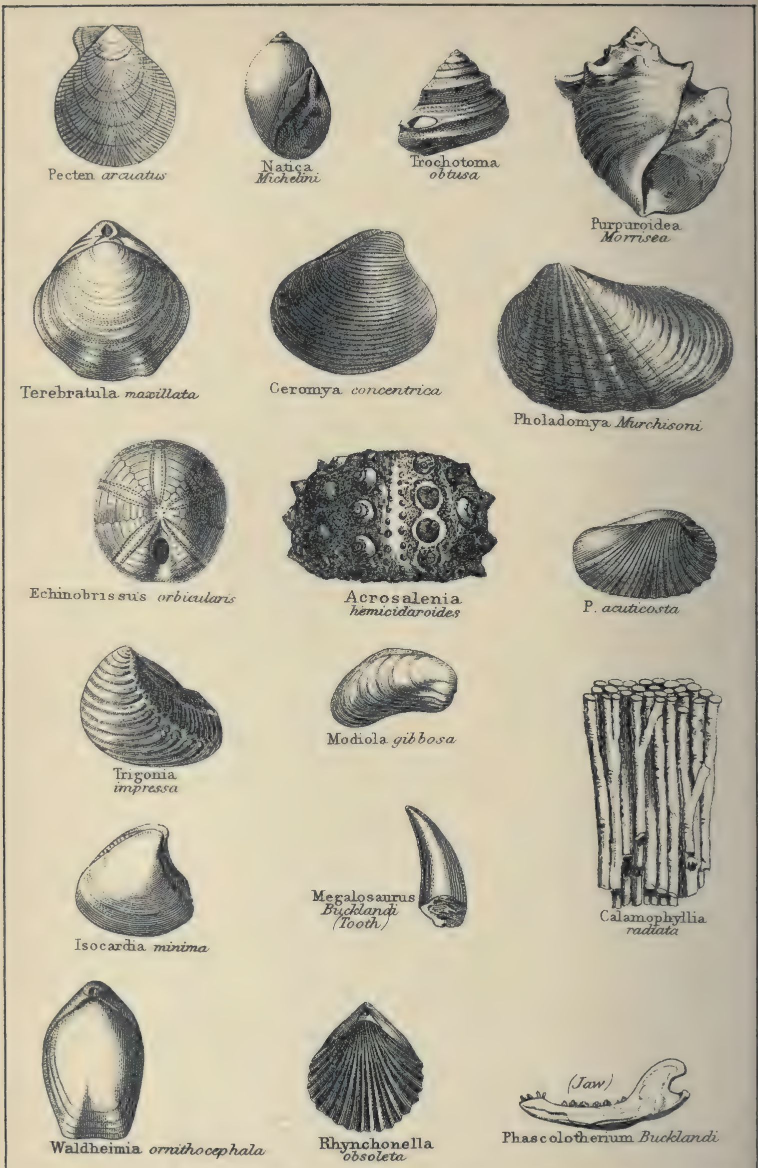
Upper & Middle Lias.



Stanford's Geog^l. Estab^t.

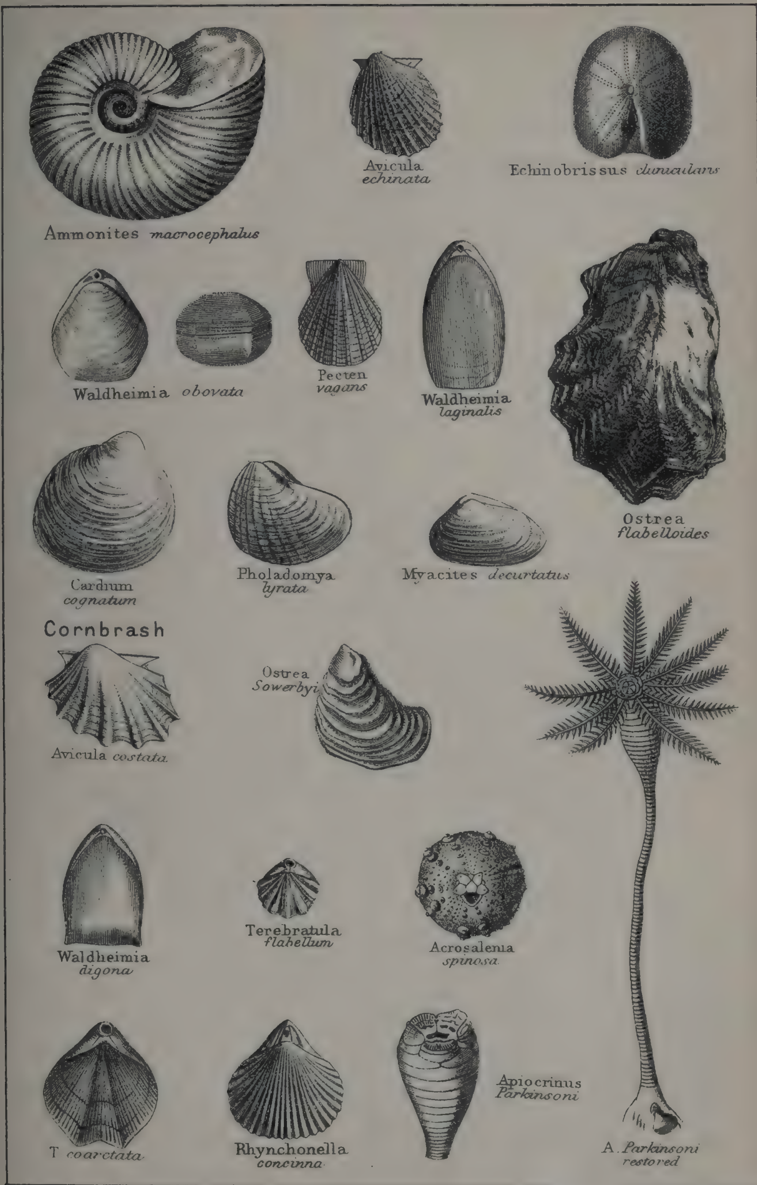
Inferior Oolite.

LOWER OOLITIC



Stanford's Geog^{l}. Estab^{t}.

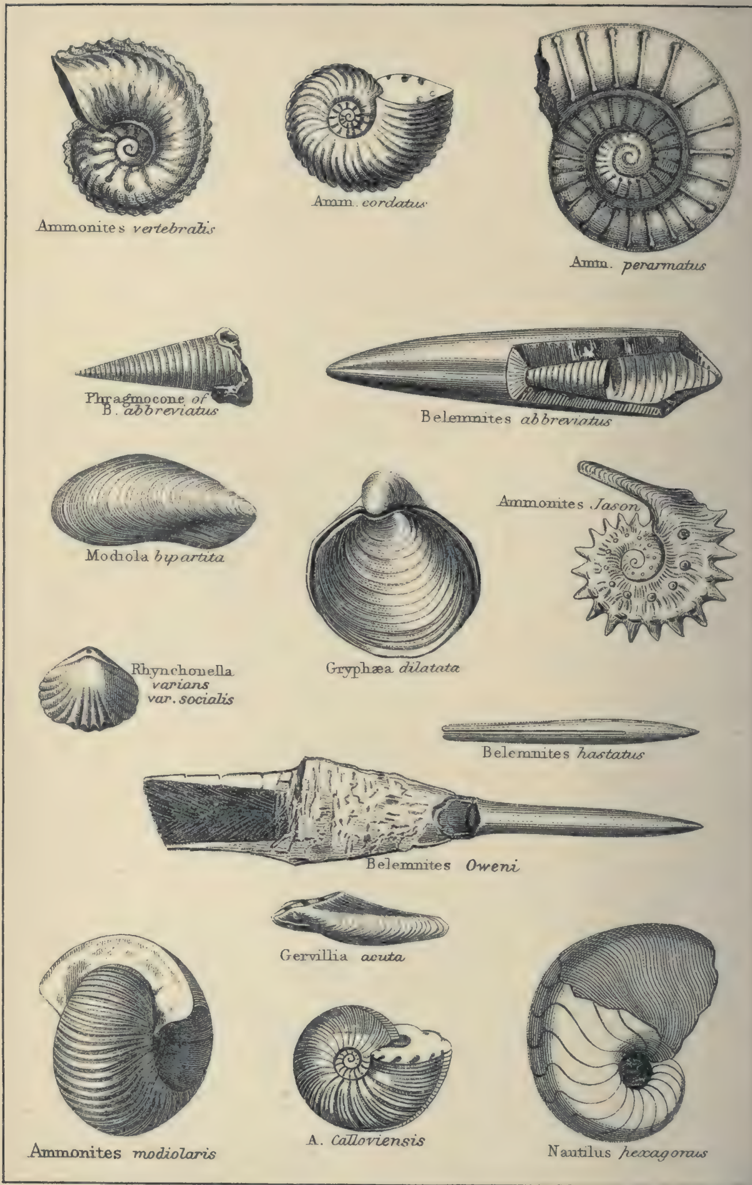
Great Oolite, Stonesfield Slate & Fuller's Earth.



Stanford's Geogl Estabt

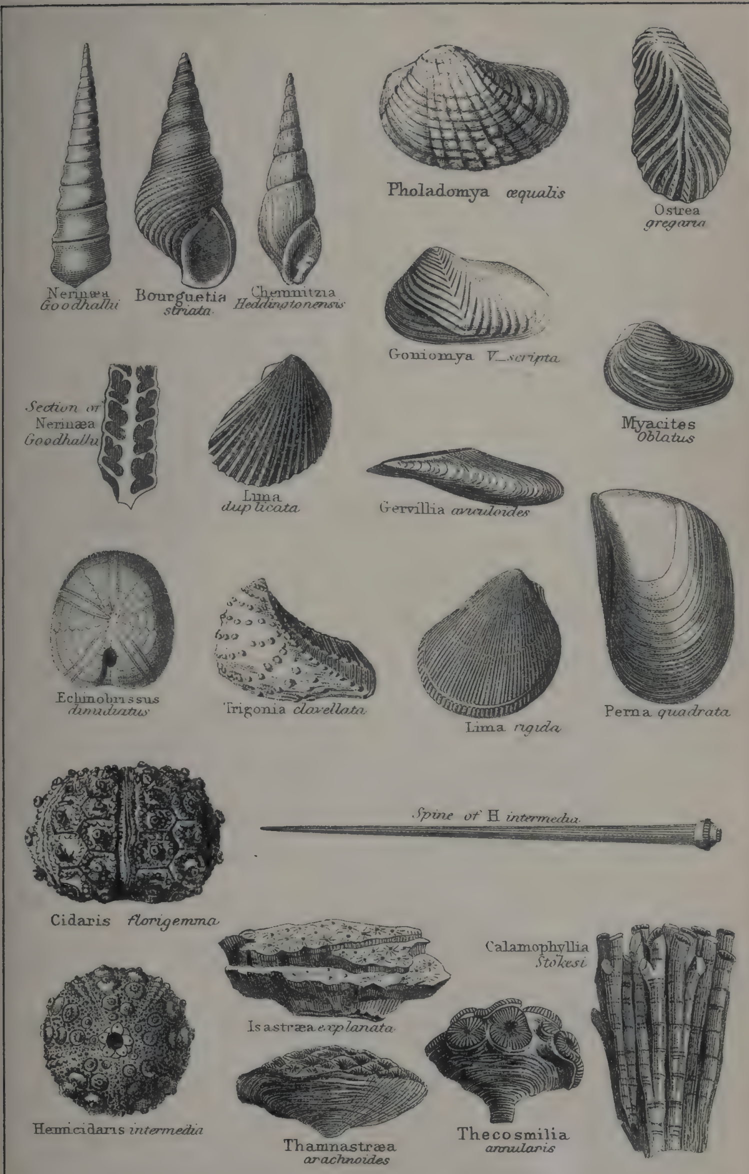
Forest Marble & Bradford Clay

MIDDLE OOLITIC



Oxford Clay & Kellaways Beds.

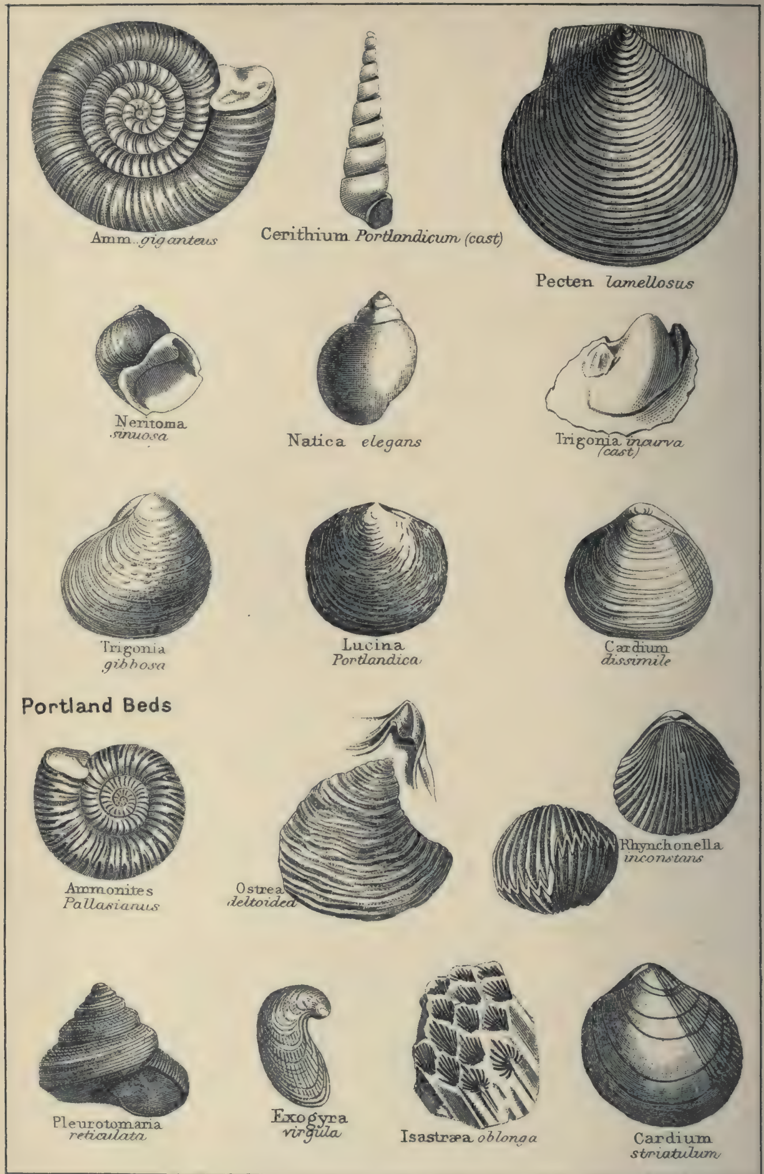
MIDDLE OOLITIC



Stanford's Geog! Estab!

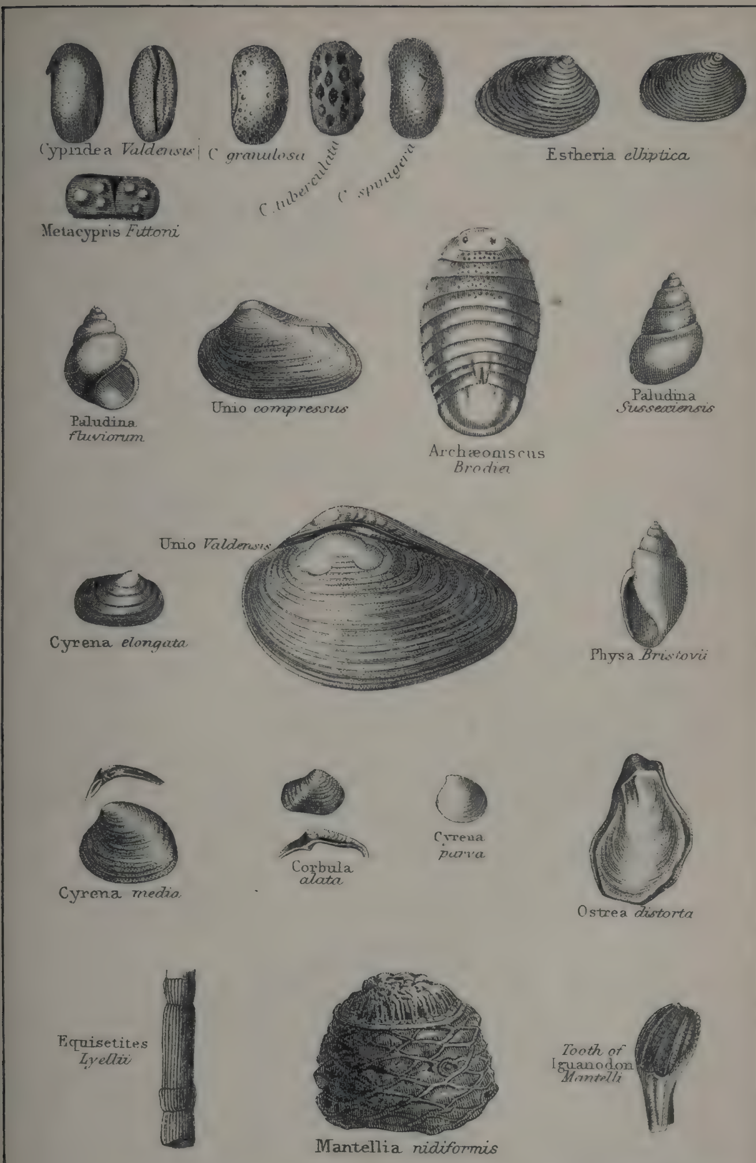
Corallian.

UPPER OOLITIC



Kimeridge Clay

WEALDEN-PURBECK



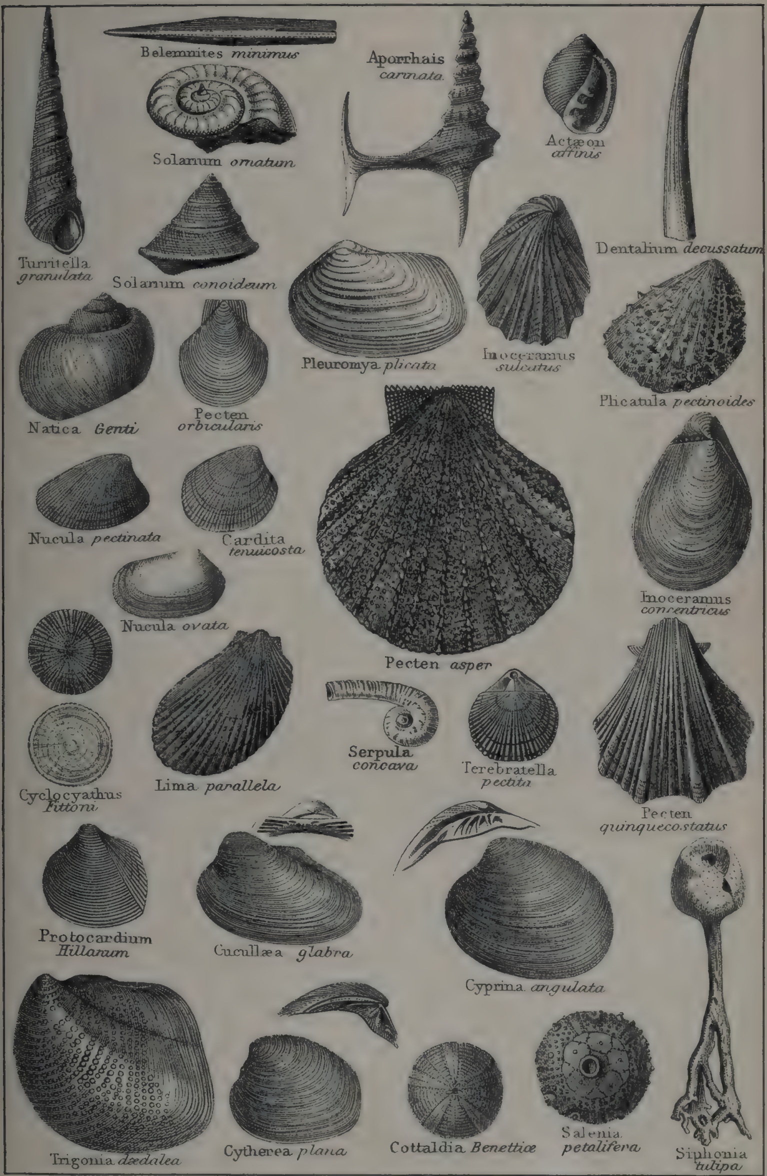
Stanford's Geog! Estab!

Purbeck & Wealden Beds.

LOWER CRETACEOUS

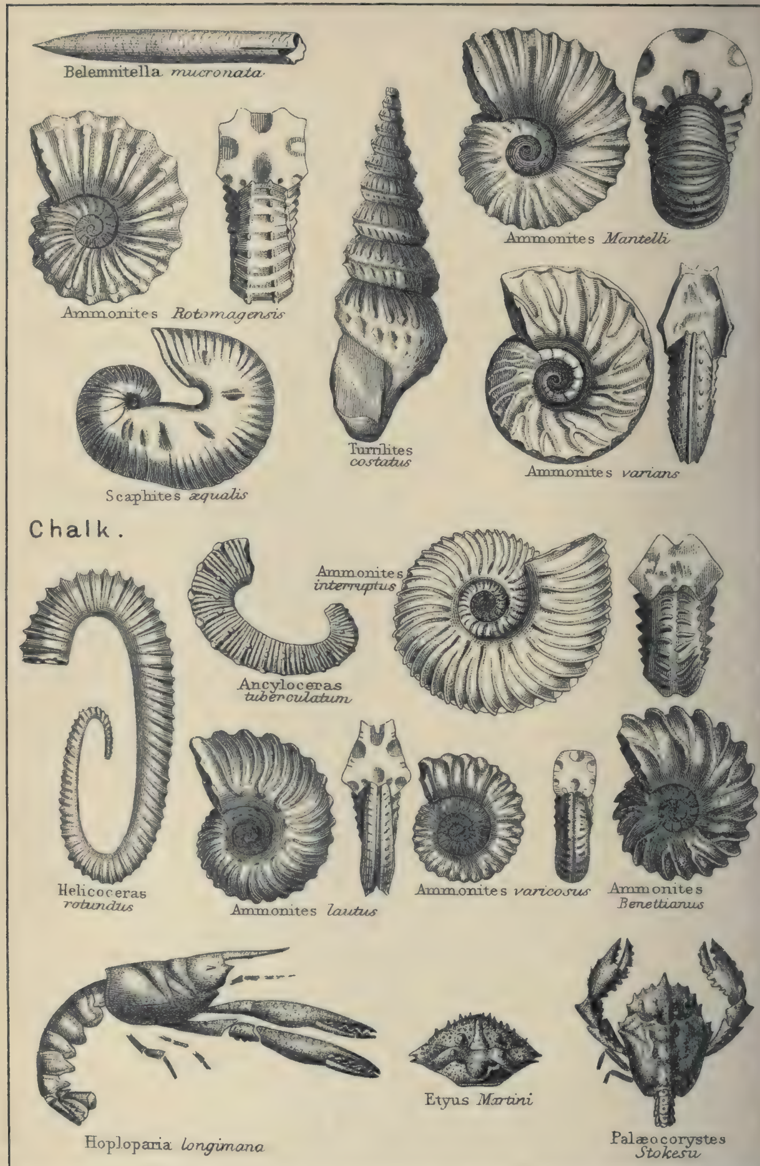
Lower Greensand.

UPPER CRETACEOUS



Upper Greensand & Gault

UPPER CRETACEOUS



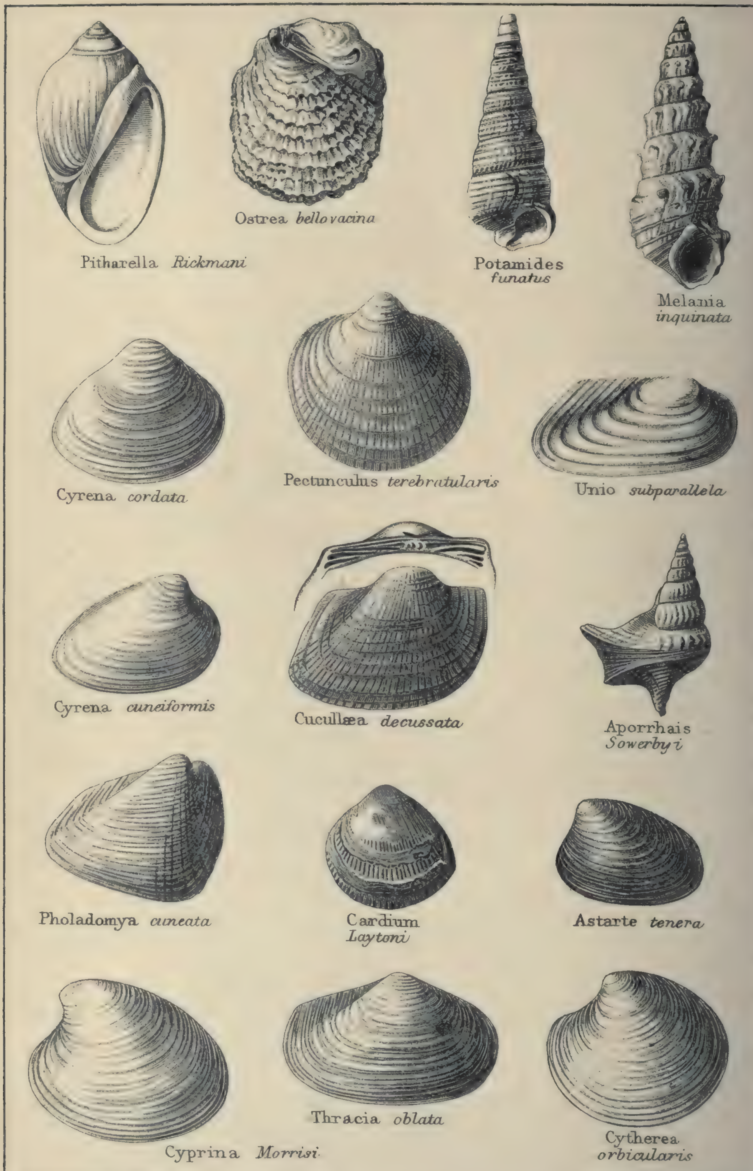
Stanford's Geog^l. Estab^t.

Upper Greensand & Gault.

UPPER CRETACEOUS

Chalk.

LOWER EOCENE

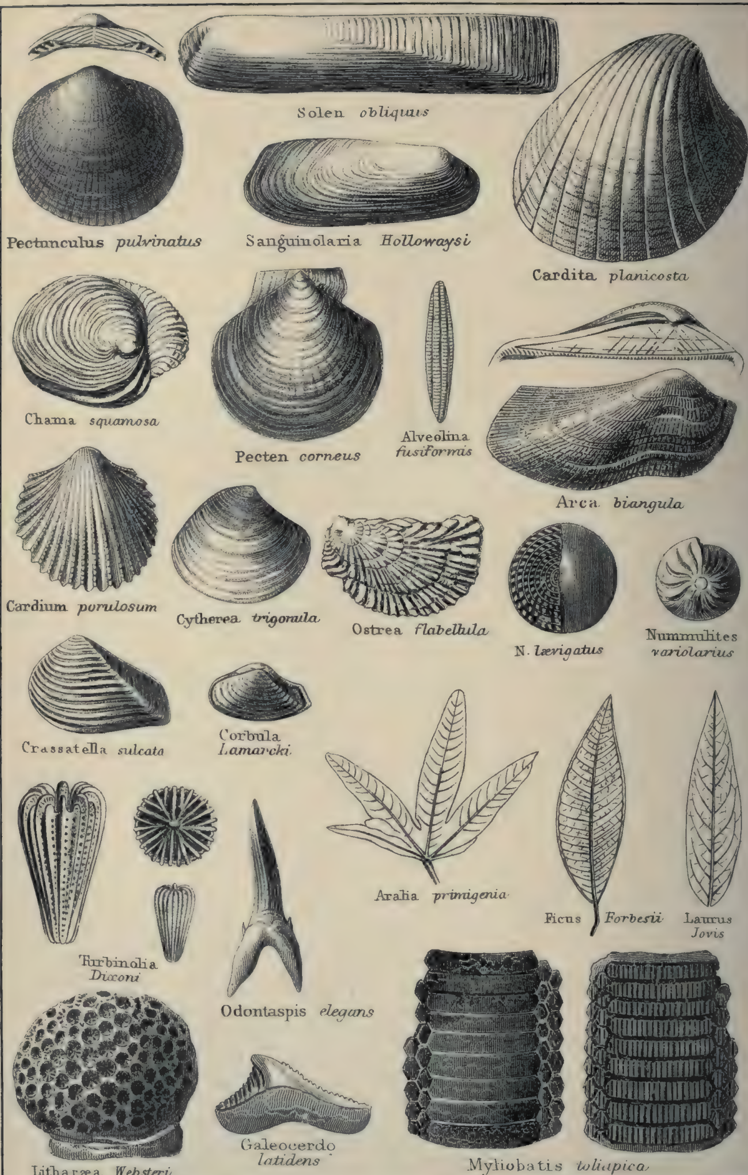


Woolwich & Reading, & Thanet Beds.

LOWER EOCENE

London Clay.

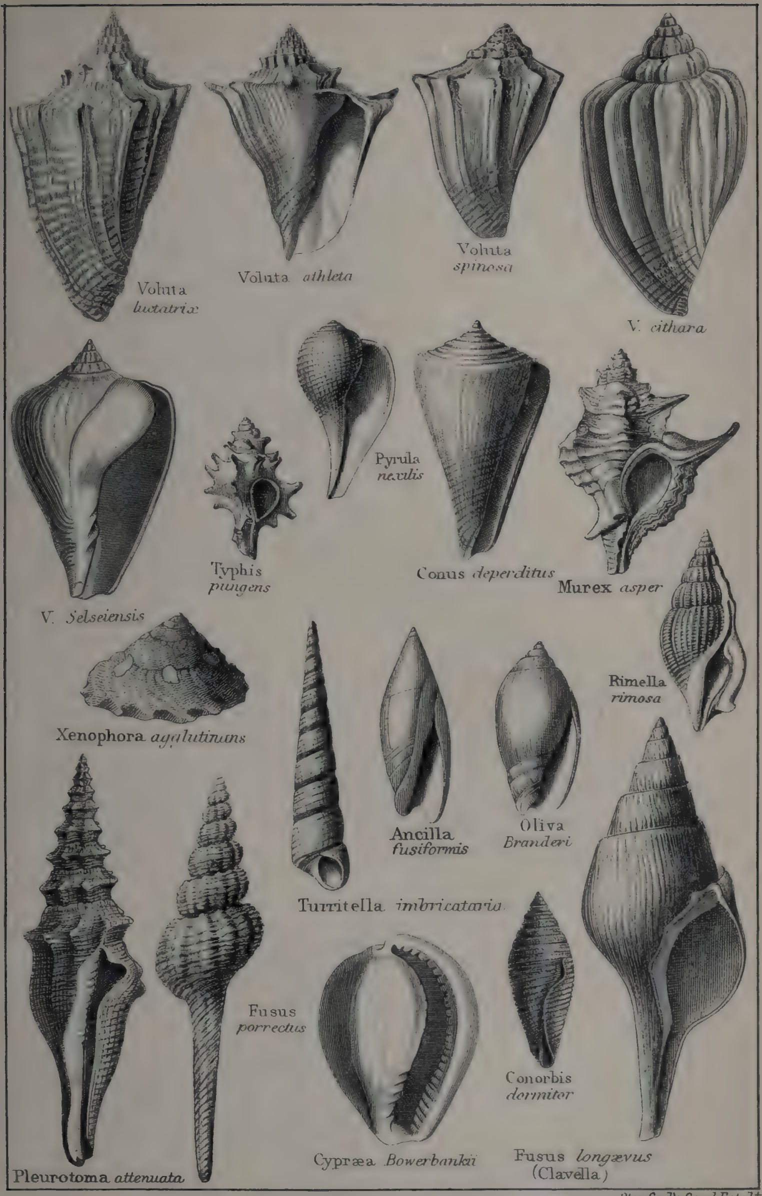
UPPER EOCENE



Stanford's Geogl. Estabt.

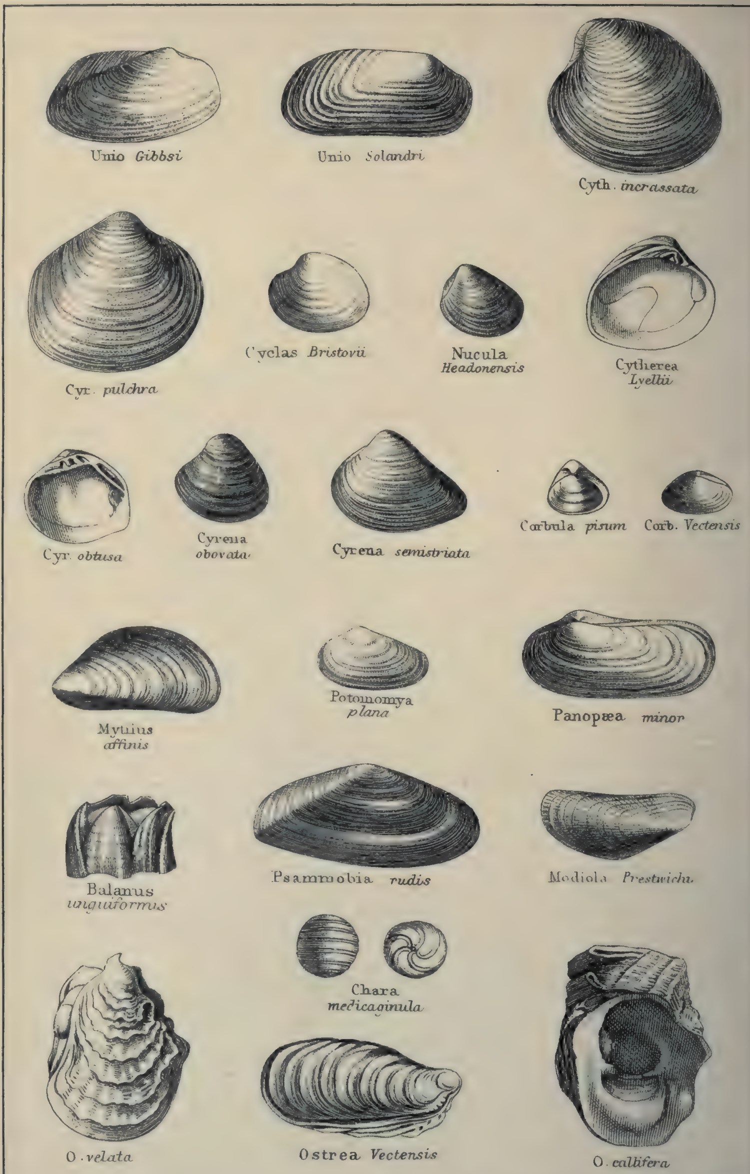
Barton, Bracklesham & Bagshot Beds.

UPPER EOCENE



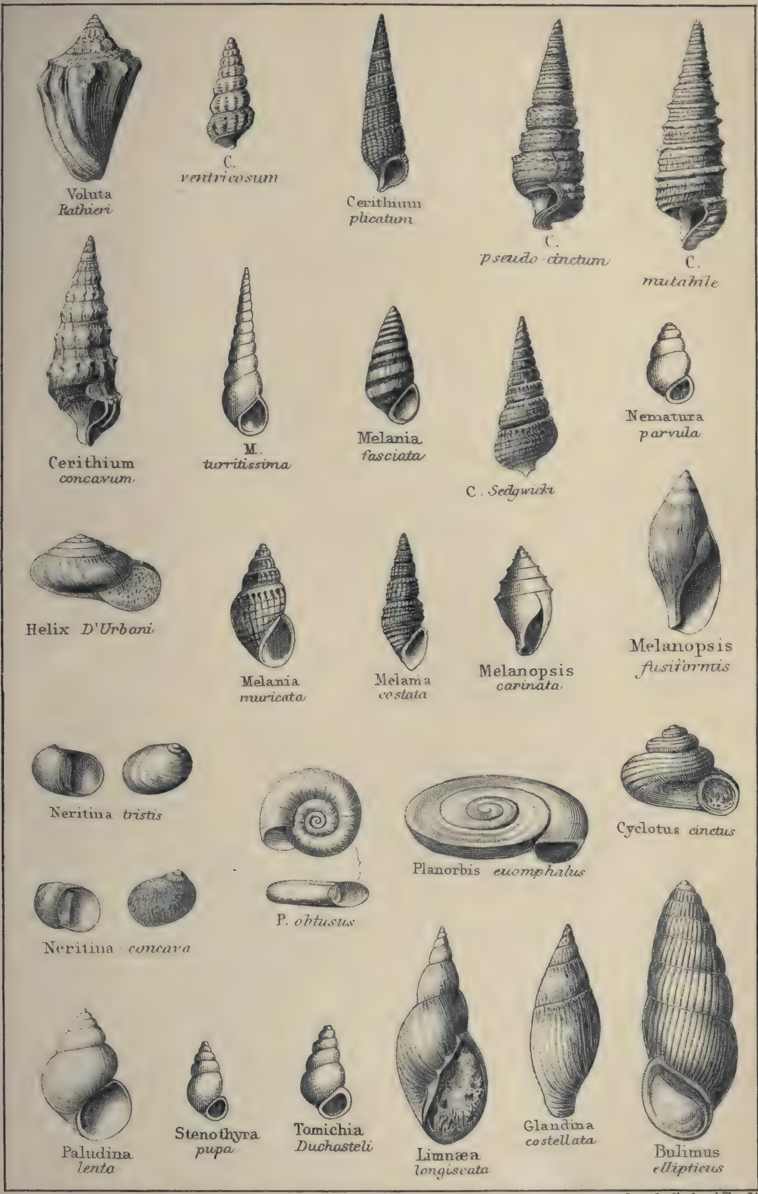
Barton, Bracklesham & Bagshot Beds.

OLIGOCENE



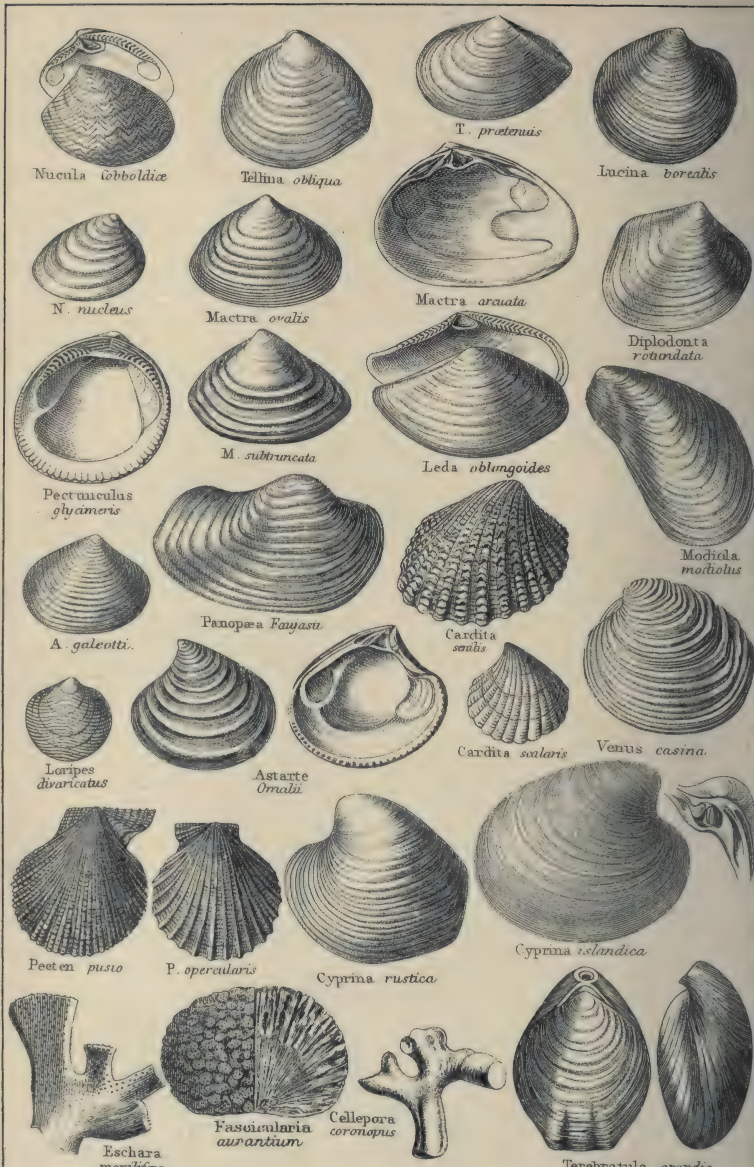
Stanford's Geog! Estab!

Headon, Osborne, Bembridge & Hamstead Beds.



Headon, Osborne, Bembridge & Hamstead Beds.

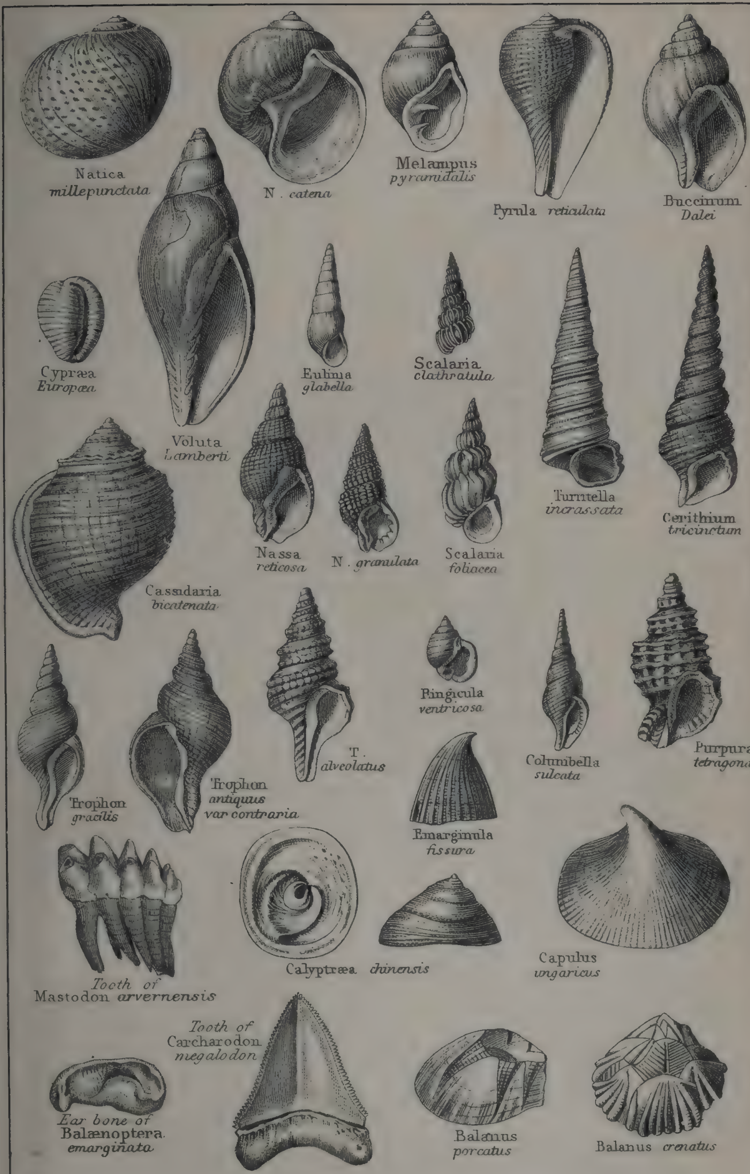
PLIOCENE



Stanford's Geogl. Estabt.

Norwich, Red, & Coralline Crag.

PLIOCENE



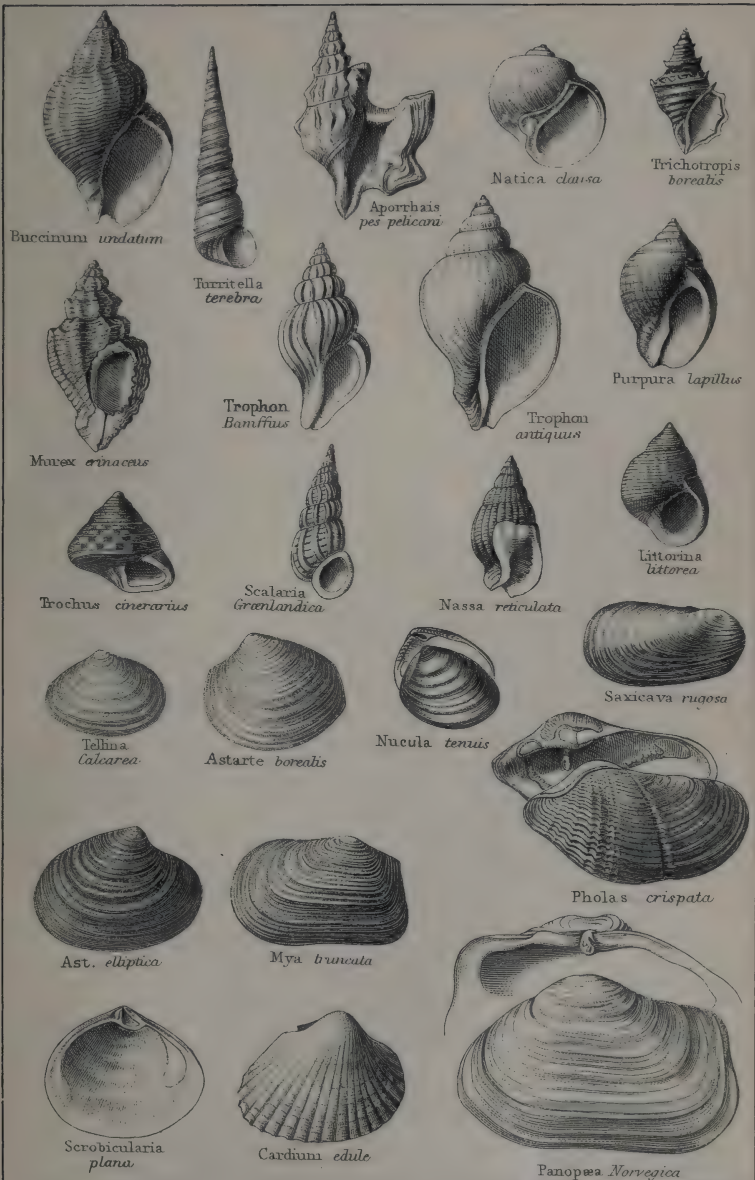
Stanford's Geogl. Estabt.

Norwich, Red, & Coralline Crag.

PLEISTOCENE

Stanford's Geog^l Estab^t

Land, Freshwater & Marine Deposits.



Stanford's Geog[l] Estab[t]

Marine Deposits.